Real Estate & Planning

Working Papers in Real Estate & Planning 08/12

Urban Growth Boundaries and their Impact on Land Prices

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Abstract

Investigation of the effects of Urban Growth Boundaries (UGB) on land prices are restricted by a lack of good land market data. However, undeveloped land transactions at the urban fringe of the Melbourne metropolitan area in Australia are recorded in a data set that enables exploration of the impact of its UGB. Estimation can take account of endogeneity issues, while controlling for policy anticipation effects and other potential influences on land prices. OLS and instrumental variable estimates indicate that land prices rose substantially inside the UGB after its enactment in 2003 but did not rise much outside of it.

Keywords

Urban growth boundary, Land prices, Land market dynamics

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R31, R52, R14

Introduction

Economic analysis of the supply-side impacts of Urban Growth Boundaries (UGBs) argues that limiting the supply of land increases the price of housing (Knaap, 1998; Nelson, 2000; Nelson et al., 2004; Voith and Crawford, 2004; Downs, 2005; Jun, 2006). The relationship seems self-evident as land is a major input to housing, so that restricting its supply will increase house prices unless other inputs are perfect substitutes, which they are not. However, actual empirical demonstration faces considerable difficulties.

There is a lack of good micro-data on land for residential development at the urban fringe. In consequence, there has been little analysis of vacant land, as Ihlanfeldt (2007) has noted; even though rises in land values are direct evidence of the consequences of introducing an UGB.

Moreover, in terms of model specification, endogeneity problems arise. Most notably, while land and house values are affected by the characteristics of local populations so are planning regulations. The presence of UGBs has additional effects, because they potentially influence where people chose to live and may encourage rent-seeking attempts to affect their delineation. Unless such inherent simultaneity is taken account of, it is difficult to identify the specific impact of UGBs on land and house prices.

The research reported here was able to deal with these issues in novel ways. It utilised unique data on vacant land sales at the urban fringe for the metropolitan region of Melbourne, Australia, a large, self-contained urban agglomeration, for a lengthy period of 12 years from 1996 to 2008. Sufficient detailed site-related information could be drawn together to control for many potential influences on land values. Policy events in this urban region also generate an ideal research environment. Melbourne for the first time introduced an urban growth boundary in 2002/3. So, a quasi-experimental approach could be adopted to investigate the impact of that legislation on land values at the urban fringe. Furthermore, good instrumental variables could be utilised to circumvent endogeneity issues. The analysis was consequently able to derive robust estimates of the impact of Melbourne's new growth boundary, identifying a substantial increase in residential land values at the urban fringe of the order of 89% for vacant land designated as lying within the new UGB.

The next section reviews the literature concerning UGB impacts on land, housing supply and land prices. Following that, the policy and housing market background to the introduction of Melbourne's UGB is examined. A methodology section then describes the dataset, sample design and modelling approach. The findings are subsequently discussed and some concluding comments made.

Previous research on UGBs and Land Prices

There is a growing literature on housing supply, as recently surveyed in Ball et al. (2010) and earlier in Olsen (1987), Bartlett (1991) and DiPasquale (1999). An important strand of work within it identifies significant planning constraints that limit supply in a number of countries. Two principal methodological approaches are utilised in these studies.

First, cross-sectional modelling is undertaken of land or housing prices across jurisdictions categorised on the basis of the restrictiveness of their land use regulations (Green, 1999; Pryce, 1999; Mayo and Sheppard, 2001; Xing et al., 2006; Ihlandfeldt, 2007; Gyourko et al., 2008; Saks, 2008; Glaeser and Ward, 2009). However, as regulatory systems are often complex, the relative degree of regulatory constraint is difficult to measure and continuous measures are unavailable. Proxy measures can be utilised but they may be subject to multivariate causality. For example, Glaeser et al (2006) utilise housing density in this way. Others identify planning constraints via minimum density requirements and other regulations (Green 1999), or count the number of land use and building regulations applied by a jurisdiction (Malpezzi 1996). Controls for cross-jurisdiction variations for demographics, income and so on are employed in such models but omitted variables are of concern in this approach. For example, residents with unmeasured characteristics that are correlated with house and land prices may purposefully select to live in jurisdictions with more or less restrictive controls.

Second, quasi-experimental studies are undertaken (Anthony, 2003; Bramley and Leishman, 2005; Wilkins et al., 2006; Cheung et al., 2009). Panel data are used to enable identification of treatment areas where a land use regulation, such as an UGB, is present and control areas where it is absent (Anthony, 2003; Cunningham, 2007; Groves and Helland, 2002; McMillen and McDonald, 2002;Sims and Schuetz, 2009). The areas are defined in various geographic ways, such as provinces, states, cities or local government areas. The ‘before and after’ experiments use observations on land or house prices prior to a measure’s introduction as the internal controls; while observations in ‘policy on’ periods are the treatments[i]. The time series properties of these studies offer opportunities to study the impact of land use regulations in study designs less vulnerable than cross-sectional modelling to omitted variable and selection bias issues. Time invariant omitted variables can be safely ignored through differencing price variables and also by assuming parameter stability. Even where regulations are suspected of being endogenous, instrumental variable estimators may be a convincing alternative, particularly if they are the product of a natural experiment (Hilber and Vermeulan, 2010).

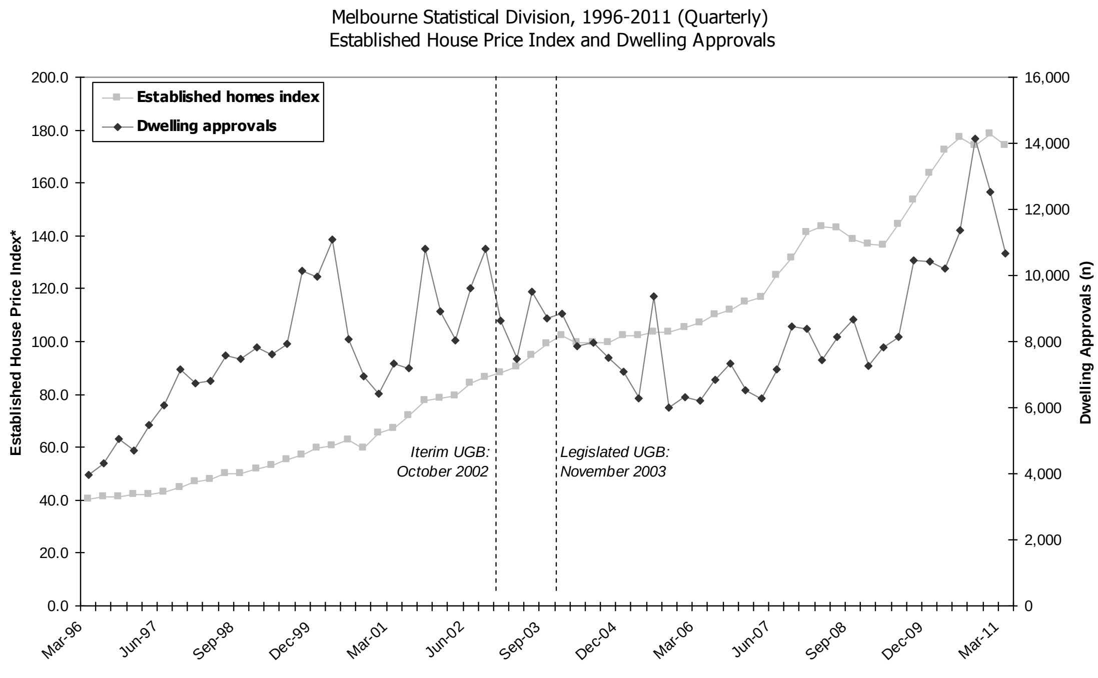
With regard to UGB impacts specifically, the literature tentatively supports the hypothesis that UGBs increase land and housing prices (Dawkins and Nelson, 2002). Jun (2006) argues that "although the evidence is not overwhelming, there are many empirical studies indicating that UGBs and other means of urban containment lead to higher land prices by limiting the supply of developable land" (p239).

Melbourne's Urban Growth Boundary

A formal Urban Growth Boundary (UGB) was introduced with the purpose of providing "a new and easily understood way of defining where urban growth will be encouraged or not permitted" (Department of Sustainability and Environment, 2002). An interim form was introduced in October 2002 and, following a consultation period, the final boundary was enacted in November 2003. Changes to the UGB require the state government to pass enabling legislation through Parliament, making it quasi-permanent in character.

Critics blame urban containment measures for a contraction in housing supply and a housing affordability crisis in Melbourne and other Australian cities (Smith and Marden, 2008). Planners and housing developers in Melbourne agree that the price of land inside the UGB has increased by more than it would otherwise have done (Goodman et al., 2010; Coiacetto, 2006).

Figure 1: Housing supply and housing prices – Melbourne
ABS



Source: Australian Bureau of Statistics Figure 1 shows house prices and new dwelling supply for Melbourne between 1996 and 2011. The price index is the established (existing) house price index for Melbourne (Australian Bureau of Statistics, 2011).

Second-hand house prices rose steeply over the study period, increasing by 215% between 1996 and 2002 and by a further 197% from 2002 to 2011 when the UGB was in place (see Figure 1). It should be noted that the index is not quality-adjusted and covers metropolitan wide transactions, both inside and outside the UGB.

Over the same time period, the correlation between dwelling approvals and house price levels was weak. The building surge from 2009 to 2011 was influenced by temporary subsidies for first-time buyers and public housing construction.

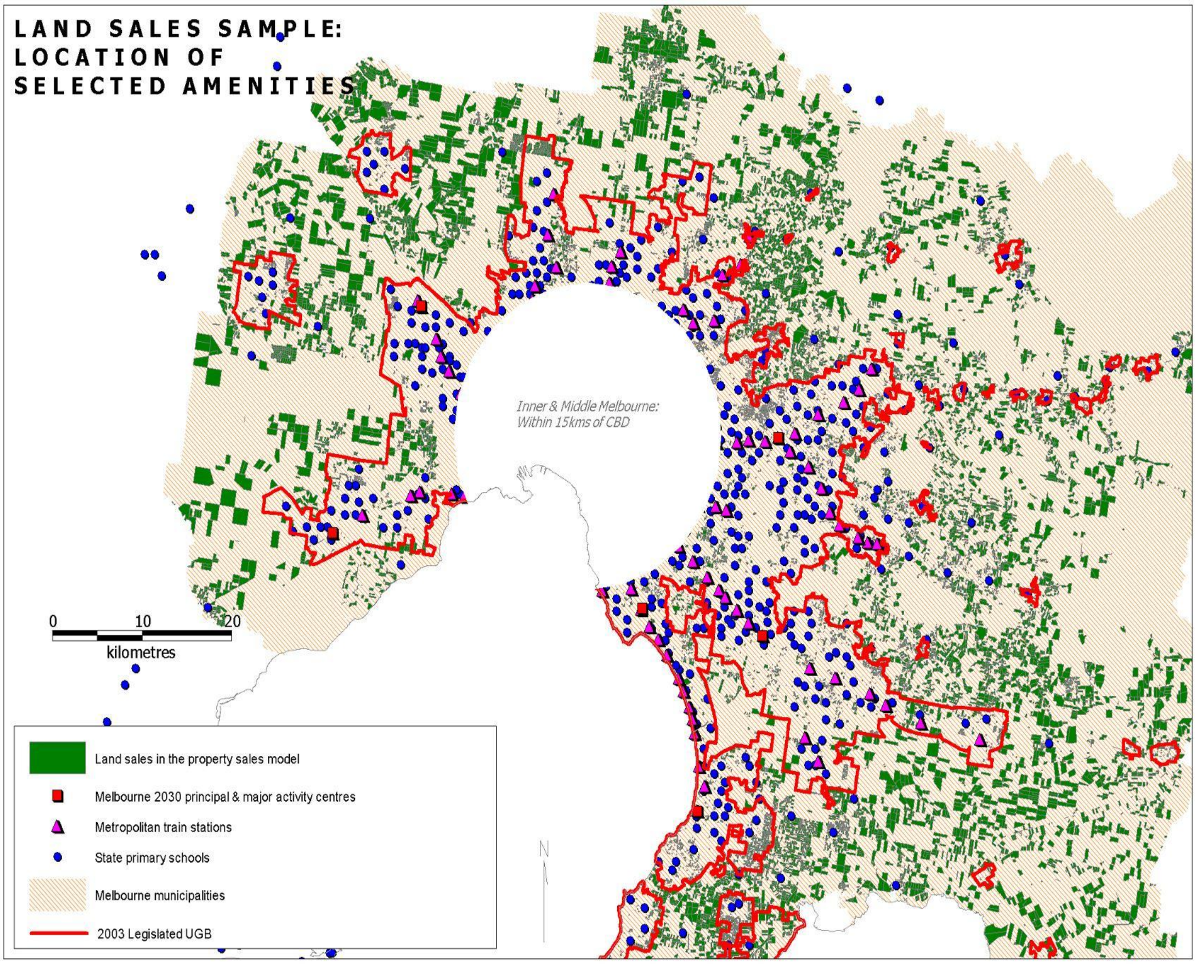
Data sources and sample design

Data on land parcels (characteristics such as size and price) were assembled across all of Melbourne's 31 municipalities from 1996–2008, using information from the Office of the Victorian Valuer-General, and they covered 89% of all land sales in the period. Further site-related information was based on a spatial reference dataset (VicMap), providing spatial information on location in relation to activity centres, urban amenities (schools, train stations, etc.), local government boundaries and planning regulations, including UGBs. Urban amenities are defined as of 2008 and, therefore, are treated as fixed effects in the modelling. A measure of the socioeconomic profile of communities (ICSEA) was sourced from the Australian Curriculum, Assessment and Reporting Authority (ACARA) (see Table 2). The boundaries of zoning and overlay areas were also identified. Overlays identify neighbourhoods with land and buildings that have idiosyncratic characteristics, for example, environmentally significant landscapes or clusters of historical buildings. Properties in areas subject to overlays must comply with additional restrictions on the use of land and the design of buildings, such as seeking permission to remove vegetation in environmentally significant areas.

From this initial dataset, a sample was selected of transactions in undeveloped land - farmland and vacant land - located at the urban fringe, defined as lying within the metropolitan area, but at more than 15 kilometres from the CBD. Restricting the sample to parcels that are within the vicinity of a jurisdictional boundary helps to control for unobserved localised amenities (Cunningham, 2007), Small parcels of less than 0.41 hectares (1 acre) were omitted. This sample restriction serves to select large land parcels that are *sold before subdivision for development*. It limits land transactions to those involving purchases by developers, rather than a mix of developers and home buyers, where the latter would be acquiring land on which they plan to build their own home. The final sample contained 8074 vacant land parcel transactions: 2197 inside the urban growth boundary and 5877 outside it.

The map in Figure 2 shows Melbourne's UGB. It has a continuous, if jagged, border on the fringe of the city with additional non-contiguous boundaries defining areas surrounding some established towns more distant from the city centre. Train stations, important local activity centres and primary schools are also shown. The land sites used in the final sample are plotted on the map, showing a spread of transactions across most of the urban fringe; 78% of them are zoned as rural, 13% zoned for residential and a further 19% for business and industrial use. After 2003, the UGB was integrated into the prior zoning system by designating land parcels previously zoned rural and within the UGB as now potentially available for conversion to residential use. With respect to zoning overlays, the most common are those related to environmental significance, covering 22% of all parcels in the sample and wildfire management (16%). Only 1% of the sample's land parcels are subject to a heritage overlay because most neighbourhoods of historical significance are located closer to the CBD. Land sizes in the sample vary widely, with some farming properties of 40 hectares or larger, though most (56%) are between 0.41 and 5 hectares in size.

Figure 2: **Land sales and location of amenities (activity centres, train stations, primary schools)**



Source: The Urban Growth Boundaries, schools, train stations and activity centres have been mapped using Vicmap, spatial reference dataset that is produced and managed by Spatial Information Infrastructure, Department of Sustainability and Environment.

Real median land prices from 1996 to 2008 are plotted in Figure 3 in order to describe land price changes within and outside the designated UGB before and after its introduction. Real land prices within the UGB are consistently higher, reflecting closer proximity to the CBD and the existing amenities in those localities. However, the difference in the ratios of the two sets of land prices alters over time. In years prior to 2002, land price growth was modest relative to later years across the entire urban fringe, with the exception of a one year UGB pre-announcement price surge on land expected to be designated as lying within it. In contrast, after the enactment of the formal UGB, vacant land prices rose at a much faster rate within the designated area than outside its boundary.

The impact can most clearly be described by examining the differences over time in the log prices of land parcels lying inside and outside the UGB. This difference is shown in Figure 4 which, in addition, highlights the distinct price reactions occurring for already developed and vacant greenfield land.[ii]

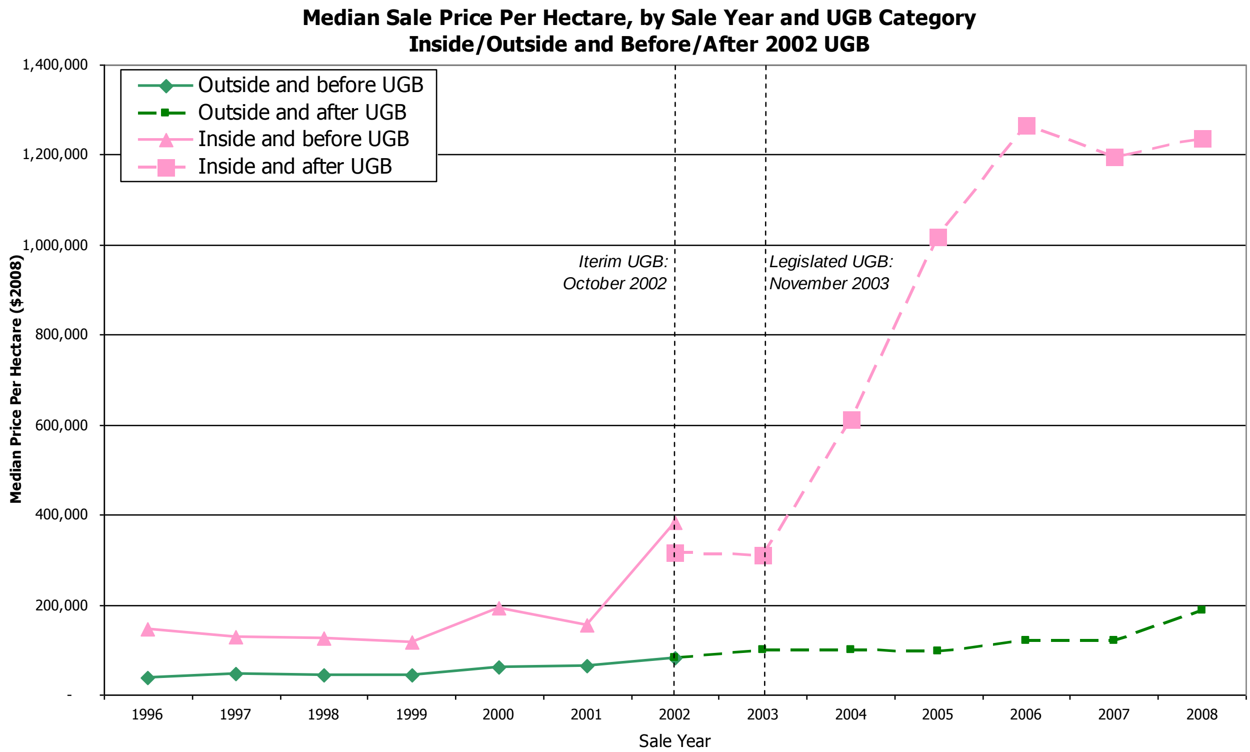
With regard to vacant land, the 'within the UGB' premium changes notably over time. There are clear indications of pre-announcement rises in the premium and a temporary downward reaction in the quarters subsequent to enactment. But the most notable event is the substantial rise in the vacant land price premium within the boundary from 2003 onwards.

The pattern with respect to developed land, as indicated by median house prices, is distinct from that of undeveloped land. The relative prices of homes inside the boundary show no signs of an uplift following passage of the boundary legislation. These divergent developed and vacant land price patterns shed doubt on the possibility that the UGB's introduction provided signals to housing and land markets about future investment in amenities and infrastructure within the boundary, which raised within boundary land values as a result. Any anticipated or real change in amenities and infrastructure should have increased property values with or without the presence of a house on the land parcel.

Another possibility is that a higher price premium for undeveloped land within the UGB could arise because of a fall in the real option value of land outside the UGB subsequent to enactment, as landowner options there have been curtailed by UGB legislation. But as Figure 3 demonstrates, there is no fall in vacant land prices outside the UGB, as would be expected post-UGB if previously large option premiums were wiped out. Furthermore, real option values outside the UGB could have been small anyway since land price uncertainty seems to have been lower outside the UGB than inside it[iii].

Consequently, substitution effects caused by the UGB's effect of restricting the supply of land remain the most likely explanation of the divergence in vacant land prices inside and outside of the boundary. However, modelling analysis is required to address this issue, because the uplift in land prices may still have a spurious link to the designation. For example, it could have been the case that the UGB merely correctly anticipated surges in housing demand inside its boundary that did not occur outside it. The following section addresses this issue.

Figure **3**: Median land prices per hectare (A$2008)[a] by sale year and UGB status[b].

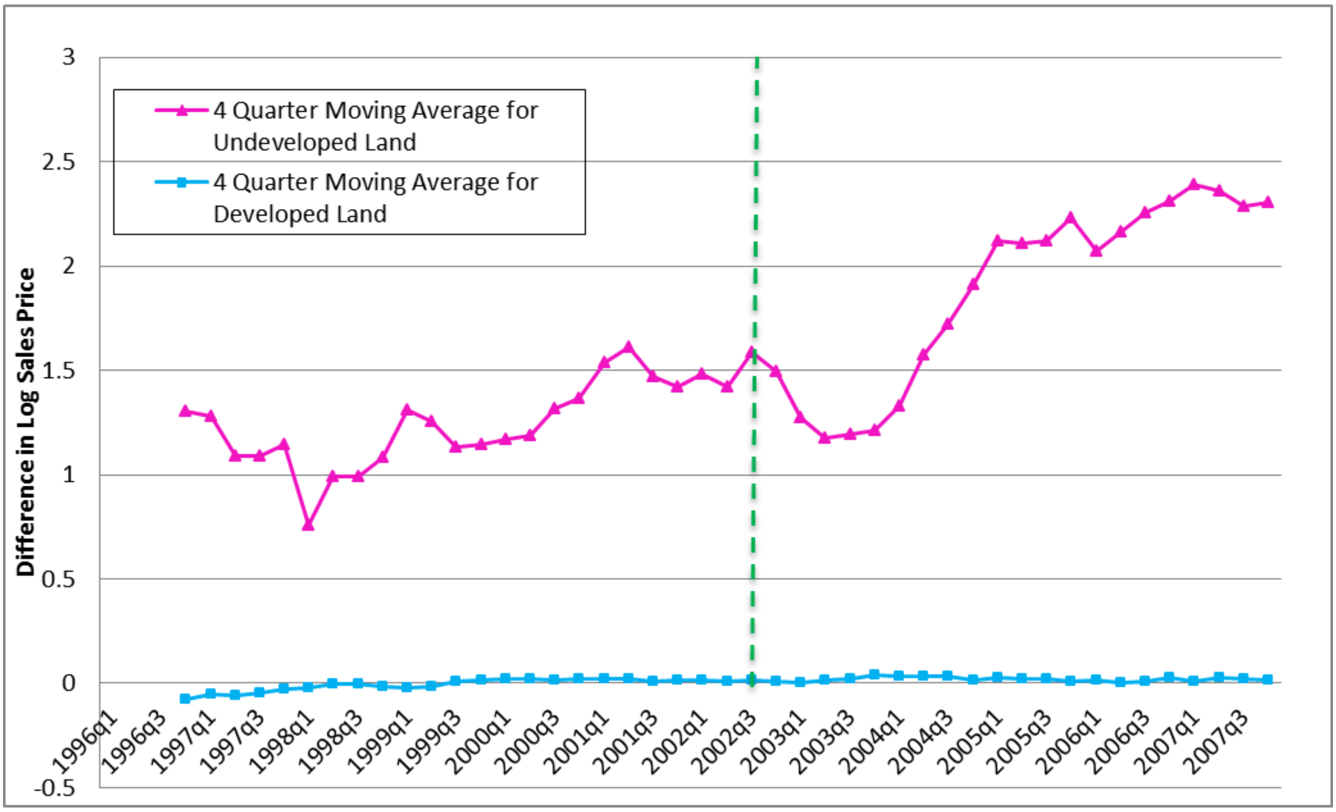


Source: *Source:* Authors computations from the Valuer General Property Transactions dataset 1996-2008.

Note: a Land prices have been converted to 2008 values using the consumer price index. (ABS Cat. 6401.0 All items index, Australia)

b The discontinuity in the year 2002 arises because transactions in the first 9 months of the year are used to calculate the median land price in the 'before UGB' part of the year, and transactions in the remaining 3 months of the year are used to compute the median land price in the 'after UGB' part of the year

Figure 4: Differences in the Median Prices of Developed[iv] and Vacant Land Plots Inside the Urban Growth Boundary Minus Outside



Source: See Figure 3

Modelling Approach

Difference-in-Differences Method

The repeated cross section nature of the data is exploited by employing a difference in differences estimator computed from the following regression model specification (Model 1):

$$Y_{it} = \alpha + \sum_k \beta_k C_{ik} + \sum_t \delta_t Q_{it} + \lambda DTreatment_i + \phi DTreatment_i * Dpost_i + \mu DTreatment_i * Announcement_i + \varepsilon_{it} \quad (1)$$

Where:

Y_{it} is the real price per hectare of land parcel i in period t;

C_{ik} is a group of time invariant structural and locational characteristics;

Q_{it} represents a set of bi-annual dummy variables;

$DTreatment_i$ is a dummy identifying vacant land parcel transactions located within the UGB;

$Dpost_i$ is a dummy variable identifying transactions after the UGB's introduction;

$Announcement_i$ is a dummy variable identifying transactions concluded within the interim period, and

ε_{it} is a normally distributed error term with zero expected value and constant variance.

The intercept α is the log of the average land price in the first half of 1996 and the coefficients δ_t capture underlying trend changes common to all land prices throughout the time period. The coefficient on $DTreatment_i$, λ, measures location effects not due to the introduction of the UGB. Land within the UGB sold for more than land outside it even before 2003. The parameter of particular interest concerns the interaction term $DTreatment_i$*Dpost, because Φ is an estimate of the change in land prices due to the UGB.[v]

Announcement effects may be important, because the intention to legislate was announced in October 2002 and interim boundaries made public for consultation purposes. Developers might respond by scrambling to acquire land parcels inside the interim UGB, with impacts on land prices magnified if landowners inside interim boundaries withhold land until the boundaries were legislated. For developers sitting on land outside the UGB the prospect of lower real option values could motivate acceleration in building construction in the short term (Cunningham, 2007). To capture these effects the interaction term $DTreatment_i*Announcement_i$ is added to equation 1. There are 332 land transactions inside the UGB in the interim period.

In a variant of this model specification, termed Model 2, the difference in differences (or average treatment effect) coefficient (ϕ) is allowed to vary across the biannual periods in the post-treatment era; although 2008 was excluded in this formulation because of limited observations. This version of the model enables examination of the dynamic pattern of average treatment effects. This is of interest because the $\hat{\phi}$ estimate could reflect an immediate sharp spike in land prices within the UGB that recedes in the post-legislation period.

Table 1 defines the key variables and their measurement. The variable ICSEA representing community socioeconomic profile is a composite measure of the socioeconomic characteristics of Australian Bureau of Statistics census collection districts. It combines measures of average income, level of education, and types of employment sourced from the 2006 Australian census with school administrative data that include the proportion of indigenous students, parent occupation, school education, non-school education and language background.[vi] Other locational effects are detected through inclusion of distances from the central business district, the nearest local activity centre; and from important urban amenities and services such as schools and train stations. Plot size is included to control the potential plattage effect of declining land prices (per hectare) with increasing size (Isakson, 1997). UGBs may be drawn in such a way as to exclude areas prone to flooding or bushfire. Overlay categories identify such areas (see above); as well as areas of heritage or environmental significance. The zoning classification of land parcels was also included. Finally, land parcels may have expensive farm buildings on them and the model specification includes an improvement dummy variable to identify when buildings valued in excess of A$20,000 are present on the land.

Table 1: Variable Definitions

VARIABLE NAME	DEFINITION	MEASUREMENT
Y	Dependent variable: log per hectare sales price of vacant land;	Nominal Dollars
Dtreatment	Dummy Variable: indicating lying within the UGB;	Equal to 1 if property sold is within the UGB;
Announcement* DTreatment	Dummy variable: properties within the UGB transacted during interim period;	Equal to 1 if within UGB and sold between Oct. 2002 and Nov. 2003;
DPost	Dummy variable indicating properties transacted after UGB;	Equal to 1 if sold from Nov. 2003 onwards,
DTreatment *Post*Q	Interaction bi-annual dummies: in the treatment group transacted after UGB;	Equal to 1 if within the UGB & sale from Nov. 2003 onwards and is in specific bi-annual period;
C	Vector of continuous and dummy variables capturing structural and locational characteristics (see below);	See below
Q	Vector of bi-annual dummies on time of sale	Equal to one if transaction in specific bi-annual period (first half 1996 is omitted category)
ICSEA (Index of Community Socio-Educational Advantage)[a]	Continuous variable that measures the socio-economic characteristics of secondary school catchment areas	Log of ICSEA value ; each land parcel is assigned the ICSEA value of the nearest secondary school
Distance to CBD	Distance to the CBD;	Log of distance to the CBD km;
Distance to train station	Distance to the nearest train station;	Log of distance to train station km;
Distance to activity centre	Distance to the nearest principal or major activity centre	Log of distance to activity centre km;
Distance to primary school	Distance to the nearest state primary school;	Log of distance to primary school km;
Distance to secondary school	Distance to the nearest state secondary school;	Log of distance to secondary school km;
Land size hectares	Size of the land parcel;	Log of the plot in hectares;
Rural zone dummy	Dummy variable: area zoned for rural development;	Equal to 1 an area zoned as residential, (omitted category);
Residential zone dummy	Dummy variable: area zoned for residential development;	Equal to 1 if area zoned as residential,
Industrial zone dummy	Dummy variable: area zoned for industrial development;	Equal to 1 area zoned as industrial,
Business zone dummy	Dummy variable: area zoned for commercial/business development;	Equal to 1 if zoned as commercial/business,
Environmental significance overlay dummy	Dummy variable: environmental significance;	Equal to 1 if area environmentally significant,
Land subject to inundation overlay dummy	Dummy variable: area prone to flooding;	Equal to 1 if flood area,
Wildfire management overlay dummy	Dummy variable: risk of wildfire significant and threat to life and property;	Equal to 1 if wildfire area,
Heritage overlay dummy	Dummy variable: places of natural, historical or cultural significance;	Equal to 1 if heritage area,
Improvements at sale dummy	Dummy variable: improvements at sale of over A$20,000;	Equal to 1 if property improved.

Note: ICSEA values from the My School website: www.**myschool**.edu.au/. Land characteristics variables are sourced from Victorian Valuer General Property Transactions dataset and the Victorian Valuer General Property Valuations records. Distance to urban amenity variables were obtained using the Vicmap spatial reference database.

Concern over the potential for endogeneity problems in the OLS estimates arises because some of the explanatory variables could themselves be correlated with the UGB. Alternatively, it may be the case that unobservable factors related to the assumed independent variables could have influenced where the UGB was drawn. Therefore, the three variables using the UGB identifier in equation (1) could be endogenous. In that case, estimation outcomes would be biased and land value increases falsely attributed to the introduction of the UGB. A two-stage least-squares (2SLS) instrumental variable estimator, with multiple instruments, was utilised as a third model in order to account for these potential effects and the results compared with those derived from the OLS models.

Results

Ordinary Least Squares estimates

Table 2 presents the key findings for Models 1 and 2; with the former having a fixed post-UGB treatment variable and the latter having a bi-annually varying one, as outlined above. They provide tests of the proposition that land prices within the UGB are raised by its introduction. In tables 3 and 4 we also report the results for the control variables used. The reported estimates are for a data sample trimmed at 1%. However, results from the full dataset and one trimmed at 5% are similar on all the main coefficients of interest with no changes in sign or significance.[vii]

The coefficient $\hat{\phi}$ for the $DTreatment_i$*Dpost* variable is of greatest interest with respect to the UGB's impact in Model 1. It suggests that the average land price within UGBs is increased by as much as 89% due to the UGB's introduction.[viii]

Table 2 also reports the coefficient estimates for Model 2 with 9 bi-annual *DTreatment*post* dummies, rather than the single post-UGB treatment variable of Model 1. The findings indicate that the effects of the UGB's introduction are sustained, because there is no indication of $\hat{\phi}_t$ coefficients tailing off in size or statistical significance over time.

Table 2: Regression Results

VARIABLES	MODEL 1		MODEL 2	
	Coefficient	t-stat	Coefficient	t-stat
UGB Impact				
DTreatment	-.04	-1.2	-0.04	-1.2
Announcement*DTreatment	.18	3.5	0.18	3.6
DTreatment*Post	.64	15.4		
DTreatment* Post *Jul-Dec 03			0.76	6.2
DTreatment* Post *Jan-Jun 04			0.38	4.2
DTreatment* Post *Jul-Dec 04			0.62	5.8
DTreatment* Post *Jan-Jun 05			0.59	5.0
DTreatment* Post *Jul-Dec 05			0.87	8.8
DTreatment* Post *Jan-Jun 06			0.74	7.9
DTreatment* Post *Jul-Dec 06			0.55	6.6
DTreatment* Post *Jan-Jun 07			0.67	6.8
DTreatment* Post *Jul-Dec 07			0.67	7.2
No. of observations	7617		7617	
Adjusted- R-squared	0.7717		0.7720	

Note: Standard errors in parentheses * denotes coefficient statistically significant at 10%, two-tailed test; ** denotes coefficient statistically significant at 5%, two-tailed test; *** denotes coefficient statistically significant at 1% level, two-tailed test.

There is also evidence of an announcement effect, estimated at 20% of previous prices. There was a flurry of market activity at the time, which saw the average volume of land traded within the UGB increase by 90% compared with the preceding 12 months and a temporary surge in developer demand seems the likely explanation for it.

The substantial lift in land prices within the UGB after its introduction in 2003 took place against a background of accelerating land price inflation on the urban fringe. Table 3 lists coefficient estimates for the 23 bi-annual time dummies covering the period 1996-2007, and for both models 1 and 2. In the second half of the 1990s land prices are flat across the urban fringe. The new millennium marks a lift in land prices, with model 1 estimates of average percentage increases (relative to first half 1996) soaring from 32 % in first half 2000 to a peak of 226 % in second half 2007. Estimates from model 2 in the post-UGB period are very similar.

Table 3: Bi-annual Time Variable Results

VARIABLES	MODEL 1		MODEL 2	
	Coefficient	t-stat	Coefficient	t-stat
Jul-Dec 96	-0.03	-0.5	-0.03	-0.5
Jan-Jun 97	-0.08	-1.1	-0.07	-1.1
Jun-Dec 97	-0.05	-0.9	-0.05	-0.9
Jan-Jun 98	0.03	0.5	0.03	0.5
Jun-Dec 98	0.06	1.0	0.06	1.0
Jan-Jun 99	0.12	2.0	0.12	2.0
Jun-Dec 99	0.06	1.0	0.06	1.0
Jan-Jun 00	0.27	4.5	0.27	4.5
Jun-Dec 00	0.30	4.8	0.30	4.8
Jan-Jun 01	0.38	6.6	0.38	6.6
Jun-Dec 01	0.43	7.7	0.43	7.7
Jan-Jun 02	0.56	9.8	0.56	9.8
Jun-Dec 02	0.64	11.5	0.64	11.5
Jan-Jun 03	0.59	10.2	0.59	10.2
Jun-Dec 03	0.81	14.3	0.80	13.9
Jan-Jun 04	0.79	13.5	0.85	13.9
Jun-Dec 04	0.99	15.6	0.99	14.8
Jan-Jun 05	0.94	14.6	0.95	14.0
Jun-Dec 05	1.02	16.3	0.96	14.2
Jan-Jun 06	1.10	17.6	1.07	15.7
Jun-Dec 06	1.18	19.5	1.22	18.2
Jan-Jun 07	1.16	18.8	1.15	17.5
Jun-Dec 07	1.18	19.1	1.17	17.6

Note: Standard errors in parentheses * denotes coefficient statistically significant at 10%, two-tailed test; ** denotes coefficient statistically significant at 5%, two-tailed test; *** denotes coefficient statistically significant at 1% level, two-tailed test.

The results for the control variables reported in Table 4 yield some interesting insights into the factors driving land price differentials at the urban fringe. For exposition, they have been divided into plot, planning, distance and other variables.

There are two significant land parcel variables. The existence of buildings and other improvement's on site at the time of sale raises land values, as indicated by the improvements at sale dummy. This is perhaps unsurprising, given that many of the transacted sites in the sample remain in agricultural use. The existence of a plattage effect is also apparent with a decline in land prices for larger lot sizes.

Planning variables have significant impacts as well. The estimated price premiums over rural land values associated with residential, industrial and business zoning are 32%, 83% and 1.6% respectively. Overlays are also germane. Land parcels subject to risks of wildfire or flood inundation sell at significant discounts of -29% and -9% respectively. There are two plausible sources of these discounts. First, the hazard risks depress willingness-to-pay and, second, such sites face higher construction costs to mitigate those hazards which are capitalised into land price bids. Turning to the heritage and environmental significance overlays, both have potentially negative and positive demand effects. This is because the controls on what can be built depress demand but, conversely, demand is increased by constraints preserving the character of attractive neighbourhoods. The estimates in Table 4 suggest that the net outcome in heritage neighbourhoods is to raise land values, whereas the opposite holds in areas of environmental significance.

With regard to the distance variables, mono-centric influences on metropolitan land development are highlighted with respect to the outer suburban areas investigated here. Land prices fall with respect to distance from the CBD, though they are inelastic on the fringe with a 1% increase in distance producing a 0.2% decline in prices. Declines on the urban fringe reflect the strong pull of the CBD on activity within the metropolitan Melbourne area, in common with urban development in other Australian cities (Kulish et al., 2011). By contrast, locations close to the outer suburban activity centres are associated with a land price discount. This indicates that the urban fringe centres around which urban development will be concentrated are relatively less attractive locations. Good accessibility to other urban amenities also fails to have a positive impact on land values. For example, greater distances to primary schools actually significantly raise land prices. These results overall may reflect premiums on suburban fringe land that still retain a high environmental character once developed, rather than that negative values are assigned to either accessibility or agglomeration. Finally, the socio-economic profile of outer suburban communities is an important influence with a 1% increase in ICSEA values raising land prices by over 3%[ix].

Table 4: Control Variable Results

VARIABLES	MODEL 1		MODEL 2	
	Coefficient	t-stat	Coefficient	t-stat
Land characteristics				
Improvements at sale dummy	.39	20.0	.39	20.0
Lot size hectares (log)	-.68	-105.1	-.68	-105.0
Planning				
Residential zone dummy	.28	8.6	.28	8.7
Industrial zone dummy	.60	12.7	.61	12.7
Business zone dummy	.02	0.3	.02	0.3
Environmental overlay dummy	.17	7.9	.17	7.9
Inundation overlay dummy	-.10	-2.4	-.09	-2.4
Wildfire management overlay dummy	-.34	-14.8	-.34	-14.8
Heritage overlay dummy	.33	3.4	.32	3.4
Distance				
Distance to CBD (log)	-.20	-5.6	-.20	-5.5
Distance to train station (log)	-.02	-1.4	-.02	-1.5
Distance to activity centre (log)	-.08	-3.4	-.07	-3.4
Distance to primary school (log)	-.04	-3.0	-.04	-3.0
Distance to secondary school (log)	.01	1.0	.01	1.0
Socioeconomic Indicator				
ICSEA (log)	3.42	11.2	3.45	11.3

Note: Standard errors in parentheses * denotes coefficient statistically significant at 10%, two-tailed test; ** denotes coefficient statistically significant at 5%, two-tailed test; *** denotes coefficient statistically significant at 1% level, two-tailed test.

Instrumental Variable Estimates

Endogeneity was investigated using the Durbin-Wu-Hausman test on the residuals from reduced forms for the UGB variables. The test results highlighted evidence of endogeneity with respect to each of the variables involving the UGB indicator at the 0.001 level of significance. This finding prompted use of a two-stage least-squares (2SLS)/IV estimator based on two instruments:

(i) a dummy variable to denote whether the site is in an ecologically significant area; and

(ii) the mean temperature in the winter months;

The data for each instrument was obtained from the Victorian state government's Department of Sustainability and Environment's Vicmap Native Vegetation Spatial data and the Australian Bureau of Meteorology.

Each instrument can intuitively be recognized as exogenous. Most home owners and tenants are likely to be unaware of the ecological significance of land surrounding their residence and, so, it is unlikely to influence their willingness-to-pay and, hence, developer land price bids. Mean winter temperatures (MWTs) differ by only a few degrees; with the lowest MWT 9 degrees centigrade and the highest 15 degrees. These minor variations are unlikely to affect location decisions and land prices.

Spearman's *rho* confirms a statistically significant association between each of the instruments and UGB status[x], while instrument relevance is confirmed by a Cragg-Donald Wald F test statistic. It verifies the strength of these instruments in first stage reduced-form regressions (Stock and Yogo, 2005). Moreover, a Sargan and Basmann test for instrument exogeneity cannot reject the null that these instruments are valid at the 0.10 level of significance.

A standard 2SLS/IV, with OLS estimation of reduced forms in the first stage, provides consistent estimates only when the dependent variables in the reduced form equations are continuous. However, the three endogenous variables associated with the UGB indicator used in the models here are dichotomous in form. As a result, the OLS estimates at the first stage are going to be inefficient, due to heteroscedasticity (Maddala, 1983). In order to overcome this problem, use was made of a modified form of the 2SLS/IV estimator, which is commonly referred to as two stage probit least squares (2SPLS). In this formulation, a probit regression is used to estimate the required three first stage equations, with the variables involving UGB status as the three dependent variables. So, the instruments are combined with the post and announcement dummies in probit models that estimate equations for *DTreatment, DTreatment*Post* and *Announcement*DTreatment*. The fitted values from the probit regressions are inserted in place of *DTreatment, DTreatment*Post* and *Announcement*DTreatment* in the second stage equation.

Table 5: IV Second Stage Results

VARIABLES	IV MODEL SECOND STAGE	
	Coefficient	t-stat
UGB impact		
DTreatment	0.05	0.9
Announcement*DTreatment	0.17	2.9
DTreatment*Post	0.75	15.4
No. of observations	7615	
Centered- R-squared	0.77	

Note: Standard errors in parentheses *** denotes coefficient statistically significant at 1% level, two-tailed test. The smaller sample size reported for the IVs arises from missing values in the instruments; these were omitted in the final regression.

The second stage IV results are reported in Table 5. The estimated coefficients for the UGB variables remain the same in terms of sign and levels of significance. According to this model, introduction of the UGB increases land prices to more than double (112%) their pre-UGB levels. This is even higher than in the OLS estimates. The IV estimates again find a positive announcement effect of 19%, which is similar to that in the OLS results.

Table 6: Time Dummy Variable Results

VARIABLES	IV MODEL SECOND STAGE	
	Coefficient	t-stat
Jul-Dec 96	-0.03	-0.4
Jan-Jun 97	-0.08	-1.2
Jun-Dec 97	-0.05	-0.8
Jan-Jun 98	0.03	0.5
Jun-Dec 98	0.06	1.0
Jan-Jun 99	0.12	1.9
Jun-Dec 99	0.06	1.1
Jan-Jun 00	0.27	4.5
Jun-Dec 00	0.29	4.7
Jan-Jun 01	0.38	6.6
Jun-Dec 01	0.43	7.7
Jan-Jun 02	0.56	9.7
Jun-Dec 02	0.64	11.4
Jan-Jun 03	0.60	10.2
Jun-Dec 03	0.80	14.0
Jan-Jun 04	0.77	13.0
Jun-Dec 04	0.96	15.2
Jan-Jun 05	0.92	14.2
Jun-Dec 05	1.00	15.7
Jan-Jun 06	1.07	16.9
Jun-Dec 06	1.14	18.6
Jan-Jun 07	1.13	18.3
Jun-Dec 07	1.15	18.4

Note: Standard errors in parentheses *** denotes coefficient statistically significant at 1% level, two-tailed test.

Tables 6 and 7 list model 3 coefficient estimates for biannual time dummies and controls for land and location characteristics. The results feature broad stability with estimates very close to the OLS findings. Furthermore, what small differences there are fail to alter the statistical significance of estimates in all but three cases (distance to train station, distance to activity centres and inundation overlay).

Table 7: Control Variable Results

VARIABLES	IV MODEL SECOND STAGE	
	Coefficient	t-stat
Land characteristics		
Improvements at sale dummy	0.41	20.0
Lot size hectares (log)	-0.67	-96.7
Planning		
Residential zone dummy	0.21	5.1
Industrial zone dummy	0.51	9.0
Business zone dummy	-0.04	-0.6
Environmental overlay dummy	0.18	8.0
Inundation overlay dummy	-0.09	-2.4
Wildfire management overlay dummy	-0.33	-14.4
Heritage overlay dummy	0.33	3.5
Distance		
Distance to CBD (log)	-0.19	-5.3
Distance to train station (log)	-0.02	-1.3
Distance to activity centre (log)	-0.06	-2.5
Distance to primary school (log)	-0.03	-2.6
Distance to secondary school (log)	0.004	0.6
Socioeconomic Indicator		
ICSEA (log)	3.397	11.0

Note: Standard errors in parentheses ** denotes coefficient statistically significant at 5%, two-tailed test; *** denotes coefficient statistically significant at 1% level, two-tailed test.

Conclusions

This study investigates the effects of UGBs on the per-hectare prices paid for large land parcels on the urban fringe. Previous research has had difficulties in pinning down the effect of UGBs on suburban land prices due to a lack of good quality data and related modelling problems.

Here, a rich, virtually matchless, source of information on a large number of large urban fringe land transactions over a 12 year period have been used to test the impact of the introduction of an UGB for the Melbourne metropolitan area in Australia. This enabled the formulation of a unique quasi-experiment, examining land prices before and after the introduction of the UGB. Many controls on other potential influences on land prices could also be incorporated, as well as policy anticipation effects. Furthermore, modelling approaches were utilised which enable the inherent endogeneity problems faced in this field of enquiry to be addressed.

The database of transactions over the period 1996-2008 enabled a sample of over 8,000 large parcels of vacant and farming land to be built up incorporating detailed site attributes alongside good price information. That sample was employed to estimate a difference-in-differences model of UGB impacts.

The results indicate that the announcement of an interim UGB in 2002 was only associated with a modest lift in land prices. However, land prices within the UGB then soared once the UGB was formally enacted in 2003, but they did not rise much outside of it. OLS estimates suggest an average treatment effect of 89%. Instrumental variable estimates find increases of a similar order of magnitude (112%). Investigation highlighted that the pattern of prices in the post-legislation period were sustained throughout to the study timeframe, which lasted up to 2007.

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Acknowledgement & Disclaimer

The Property Valuations (2008) dataset and the Property Transactions dataset used in this paper were supplied by the Office of the Valuer-General, Victoria (VGV). VGV is a division within the Department of Sustainability and Environment. It is the state's independent authority on property valuations, and oversees government property valuations and council rating valuations. The findings and views reported in this paper are those of the authors and should not be attributed to VGV.

REFERENCES

Alonso, W., 1964. Location and Land Use: Toward a General Theory of Land Rent, Cambridge, Massachusetts, Harvard University Press.

Anthony, J., 2003. The Effects of Florida's Growth Management Act on Housing Affordability, Journal of the American Planning Association **69**(3): 282.

Australian Bureau of Statistics (ABS), 2011. Cat. 6416.0, House Price Indexes: Eight Capital Cities.

Ball, M., Meen, G., Nygaard, A., 2010. Housing supply price elasticities revisited: evidence from international, national, local and company data, Journal of Housing Economics **19**(4), 255-268.

Bartlett, W., 1989. Housing Supply Elasticities: Theory and Measurement, York, Joseph Rowntree Memorial Trust Working Paper 2.

Bramley, G., Leishman, C., 2005. Planning and Housing Supply in Two-Speed Britain: Modelling Local Market Outcomes, Urban Studies **42**(12): 2213-2244.

Capozza, D., Yuming, L., 1994. The Intensity and Timing of Investment:
The Case of Land, *American Economic Review* 84 (4):,889–904.

Capozza, D., Yuming, L., 2002. Optimal Land Development Decisions, *Journal of Urban Economics* 51(1): 123–142.

Cheung, R., Ihlanfeldt, K., Mayock, T., 2009. The Regulatory Tax and House Price Appreciation in Florida, Journal of Housing Economics **18**(1): 34-48.

Coiacetto, E., 2006. Real Estate Development Industry Structure: Consequences for Urban Planning and Development, Planning Practice & Research **21**(4): 423-441.

Cunningham, C. R. (2007) Growth Controls, Real Options and Land Development, *The Review of Economics and Statistics,* Vol. 89 92): 343 – 358.

Dawkins, C. J., Nelson, A.C., 2002. Urban Containment Policies and Housing Prices: an International Comparison with Implications for Future Research, Land Use Policy **19**: 1-12.

Department of Sustainability and Environment, 2002. Melbourne 2030: Planning for sustainable growth, www.melbourne2030.vic.gov.au Last accessed 19th June 2012.

DiPasquale, D., 1999. Why Don't We Know More About Housing Supply?, Journal of Real Estate Finance and Economics **18**(1): 9-23.

Downs, A., 2005. Smart Growth: Why We Discuss It More Than We Do It, Journal of the American Planning Association **71**(4): 367(314).

Evans-Cowley, J. S., Forgey, F. A., Rutherford, R. C., 2005. The Effect of Development Impact Fees on Land prices, Growth & Change **36**(1): 100-112.

Evans, Alan. W., 1973. The Economics of Residential Location. London, Macmillan.

Glaeser, E. L., Gyourko, J., 2003. The Impact of Building Restrictions on Housing Affordability, FRBNY Economic Policy Review June : 21-38.

Glaeser, E. L., Gyourko, J., Saks, R. E., 2006. Urban Growth and Housing Supply, Journal of Economic Geography 6: 71-89.

Glaeser, E. L., Ward, B. A., 2009. The Causes and Consequences of Land Use Regulation: Evidence from Greater Boston, Journal of Urban Economics **65**(3): 265-278.

Goodman, R., Buxton, M., Chhetri, P., Wood, G. A., 2010. Planning and the characteristics of housing supply in Melbourne, Australian Housing and Urban Research Institute, Final Report No.157.

Green, R. K., 1999. Land Use Regulation and the Price of Housing in a Suburban Wisconsin County, Journal of Housing Economics **8:** 144-159.

Groves, J. R. and E. Helland (2002) Zoning and the Distribution of Location Rents: An Empirical Analysis of Harris County, Texas, *Land Economics*, Vol. 78 (1): 28-44.

Gyourko, J., Saiz, A., Summers, A. A., 2008. A New Measure of the Local Regulatory Environment for Housing Markets: The Wharton Residential Land Use Regulatory Index, Urban Studies **45**(3): 693-729.

Halvorsen, R., Palmquist, R., 1980. The Interpretation of Dummy Variables in Semilogarithmic Equations, American Economic Review **70**(3): 474-75.

Hilber, C.A.L., Vermeulen, W., 2010. The Impact of Restricting Housing Supply on House Prices and Affordability, Final Report, Department for Communities and Local Government, November. (www.communities.gov.uk/documents/housing/pdf/1767142.pdf)

Ihlanfeldt, K.R., 2004. Introduction: Exclusionary Land-use Regulations, Urban Studies **41**(2): 255-259.

Ihlanfeldt, K.R., 2007. The Effect of Land Use Regulation on Housing and Land Prices, Journal of Urban Economics 61: 420-435.

Isakson, H. R., 1997. An empirical analysis of the determinants of the value of vacant land, The Journal of Real Estate Research **13**(2): 103-114.

Jun, M.-J., 2006. The Effects of Portland's Urban Growth Boundary on Housing Prices, Journal of the American Planning Association **72**(2): 239-243.

Knaap, G., 1998. The Determinants of Residential Property Values: Implications for Metropolitan Planning, Journal of Planning Literature **12**(3): 267-282.

Kulish, M., Richards, A., Gillitzer, C., 2011. Urban Structure and Housing Prices: Some Evidence from Australian Cities, Research Discussion Paper; RDP 2011-03, Reserve Bank of Australia.

Maddala, G., 1983. Limited-Dependent and Qualitative Variables in Econometric, Econometric Society Monographs No. 3, Cambridge University Press, New York

Malpezzi, S., 1996. Housing prices, externalities, and regulation in U.S. metropolitan areas, Journal of Housing Research **7**(2): 209.

Mayo, S., Sheppard, S., 2001. Housing Supply and the Effects of Stochastic Development Control, Journal of Housing Economics 10: 109-128.

McMillen, D. P. and J. F. McDonald (2002), Land Values in a Newly Zoned City, *The Review of Economics and Statistics,* 84(1): 62-72.

Muth, R. F., 1969. Cities and Housing: The Spatial Pattern of Urban Residential Land Use, Chicago, IL: University of Chicago Press..

Nelson, A. C., 2000. Smart Growth: Urban Containment and Housing Prices, Journal of Housing and Community Development **57**(5): 45-49.

Nelson, A. C., Pendall, R,. Dawkins, C.J, Knaap, G.J., 2004. The Link Between Growth Management and Housing Affordability: The Academic Evidence, in Downs, A., (ed.) Growth Management and Affordable Housing: Do They Conflict? Washington, D.C., Brookings Institution Press.

Olsen, E., 1987. The Demand and Supply for Housing Services: A Critical Survey of the Empirical Literature, in: Handbook of Regional and Urban Economics, Vol. 2. New York. Elsevier.

Pryce, G., 1999. Construction Elasticities and Land Availability: A Two-Stage Least-Squares Model of Housing Supply Using the Variable Elasticity Approach, Urban Studies **36**(13): 2283-2304.

Saks, R., 2008. Job Creation and Housing Construction: Constraints on Metropolitan Area Employment Growth, Journal of Urban Economics 64: 178-195.

Sims, K., Schuetz, J., 2009. Local regulation and land-use change: The effects of wetlands bylaws in Massachusetts, Regional Science and Urban Economics **39**(4): 409.

Smith, M., Marden, P., 2008. Conservative think tanks and public politics, Australian Journal of Political Science **43**(4): 699-717.

Stock, J. H. and Yogo, M., 2005. Testing for Weak Instruments in Linear IV Regression, Ch. 5 in: Stock, J. H and Andrews, D. W. K. (Eds), Identification and Inference for Econometric Models: Essays in Honor of Thomas J. Rothenberg, Cambridge University Press.

Voith, R. P., Crawford, D.L., 2004. Smart Growth and Affordable Housing, in Downs, A., (ed.) Growth Management and Affordable Housing: Do They Conflict? Washington, D.C., Brookings Institution Press.

Wilkins, J., Riall, B. W., Nelson, A. C., 2006. Does Rural Land-use Planning and Zoning Enhance Local Economic Development?, Economic Development Journal **5**(4): 24-33.

Wooldridge, J. M., 2009. Introductory Econometrics; A Modern Approach, Fourth Edition, Mason, OH, South-Western Cengage Learning.

Xing, X., Hartzell, D. Godschalk, D. R., 2006. Land Use Regulations and Housing Markets in Large Metropolitan Areas, Journal of Housing Research **15**(1): 55.

Zorn, P. M., Hansen, D. E., Schwartz, S. I.,1986. Mitigating the Price Effects of Growth Control: A Case Study of Davis, California, Land Economics **62**(1): 46-57.

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[i] Cunningham (2007) analyses the impact of growth management controls on the timing of development.

[ii] See also Cunningham (2007, Figure 3) where a similar exercise is reported for King County, Washington.

[iii] Capozza and Li (1994, 2002) determine the expected return at the urban-rural frontier that is just sufficient to warrant sacrifice of real options in favour of development now. Their model predicts that this expected return will increase with price volatility because volatility raises the option premium. Models that regress the 4 quarter moving average land price (per hectare) on the 4 quarter lagged average have been estimated for the areas inside and outside the UGB, The mean square error is higher inside the UGB.

[iv] Median prices for developed land parcels are based on prices for detached houses only. There are 666,880 transactions in detached houses inside the UGB and 57,009 outside of the boundary. Extreme price values for developed land parcels were removed at the 1^{st} and 99^{th} percentile.

[v] Strictly speaking the coefficient Φ is not the simple difference in differences estimator that is obtained from an OLS regression without controls, but it has a similar interpretation (see Wooldridge, 2009, p454). Separate regressions using quarterly time dummies were also run. The size, signs and level of significance on the main coefficients were all very similar. Results can be obtained from the authors on request.

[vi] See Australian Curriculum Assessment and Reporting Authority (2010) Guide to Understanding ICSEA available at http://www.acara.edu.au/default.asp.

[vii] These results can be obtained on request from the authors.

[viii] The percentage change is obtained from 100* $\left\lfloor \exp\left(\hat{\phi}\right) - 1 \right\rfloor$ (Halvorsen and Palmquist, 1980).

[ix] The ICSEA has a mean sample value of 973 and standard deviation equal to 28.9.

[x] Spearman's rank correlation coefficient results suggest a statistically significant relationship between UGB status and the two instruments, biodiversity (rho=0.2263) and mean temperature (rho=0.2806).