THE MARGINAL COST OF A BEDROOM: AN AUSTRALIAN CASE STUDY

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ABSTRACT

After a long period of decline, a slight increase in household size in Australia has been observed in recent years. This reversal, in part, is due to a noticeable change in household formation patterns. An increase in multigenerational households and group living has been coupled with policy incentives aimed at reversing the decrease in fertility. In this paper, the results of a hedonic analysis of the cost of housing additional household members using Melbourne metropolitan sales data are presented. Specifically, estimates of the marginal price of an additional bedroom are discussed. The results show that the true cost of housing additional household members has increased substantially. Further, increasing marginal costs are evident for growing households, as captured by rising shadow prices for third, fourth and fifth bedrooms.

Keywords: hedonic analysis, marginal cost, bedroom, multigenerational households

INTRODUCTION

The importance of demographics on housing markets is well known (Reed and Forster-Kraus 2011). In Australian capital cities it has been observed in recent years that more families are engaging in multigenerational cohabitation (Liu and Easthope 2012). Furthermore, there has also been a noticeable increase in fertility rates (Sinclair, Boymal and de Silva 2012). In this paper, a set of estimates pertaining to the marginal cost of a bedroom is presented and assessed, an important consideration for all households increasing in size, thus revealing a market condition that is currently unknown.

The link between demographics and housing markets is formally framed by the life cycle model of housing (Rossi 1955). It highlights the dynamic nature of households' composition and related housing needs and summarises decisions to move residence as either push or pull factors. A push factor represents the situation where the current residence (or location) is unsatisfactory for current needs whereas pull factors correspond to the situation when an alternative package of housing goods is deemed more attractive than the current package (Rossi 1955).

Australia, like most well developed nations, experienced significant changes in family configurations and living arrangements in the latter part of the last century. Changes, such as later childbearing with fewer children, rising divorce rates and growth in smaller households such as childless couples and lone person households, have been long terms trends (Liu and Easthope 2012). However, more recently, there has been evidence of further changes in household form offsetting this move to smaller households with a rise in multigenerational households and group or share housing arrangements.

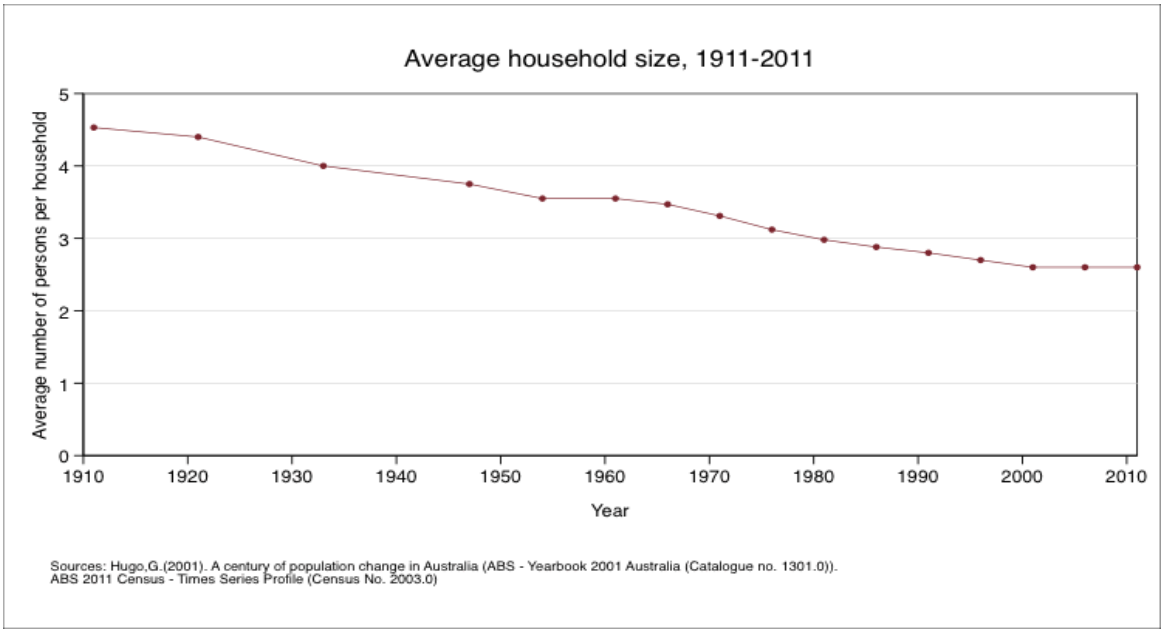
A multi generation household is defined as any household where multiple generations co-reside, where the oldest of the youngest generation is older than 18 (Liu and Easthope 2012). A group household consists of two or more unrelated people with no reported couple or family relationships in the household (ABS 2010).

In addition, there have been concerted policy efforts to address the decline in fertility. In Australia, amongst other things, the Government introduced financial incentives in the form of a "Baby Bonus" (Gray, Qu and Weston 2008) and published research indicates that this policy induced an

increase in the fertility rate from 2005 (Sinclair, Boymal, and De Silva 2012; Drago et al. 2011; Lain et al. 2009).

As a net result of these changes, there appears to be a slight increase or stabilisation in the average number of persons per household after 2005 with the average figure increasing from 2.51 to 2.57 in 2011/12. As illustrated in Figure 1, these recent changes are in contrast to the long term trend of decreasing average persons per household, with average household size in Australia falling from 4.5 in 1911 to a low of 2.51 in 2005 (ABS 2011).

Changing patterns of household composition due to changing living arrangements and changing fertility patterns are likely to affect housing demand patterns for given housing attributes, such as the number of bedrooms. Through the use of a hedonic pricing method, this research examines if there has been an associated change in the marginal cost of an additional bedroom in the last decade, relative to other housing characteristics.



Average Household Size 1911 -2010
Source: Family Facts and Figures: Australian Households;
Australian Institute of Family Studies
Figure 1

This paper presents a brief discussion of the literature relevant to changing household composition trends, in particular changes in fertility patterns, share housing and multigenerational household forms on housing demand, before describing the hedonic methods applied, and presenting the results. It concludes with a discussion on the implicit housing costs faced by expanding households.

BACKGROUND

Since 2001, household formation rates have been lower than expected on the basis of demographic patterns (NHSC 2013). If household formation growth rates slow, relative to population growth, there must be an expectation that average household size is increasing. There have indeed been a number of notable changes in the patterns of household formation in recent years. The first noteworthy change, which may impact on the preference for additional bedrooms, is the rise in multigenerational living forms. In 2006, 19% of all Australians lived in households with two or more generations of adults aged 18 and over. This was not limited to parents with children living at

home while studying, with 13.2% of all 15-44 year olds classified as non-dependent adult offspring (Liu and Easthope 2012). Liu and Easthope's (2013) analysis of multigenerational household trends in Sydney and Brisbane suggest this growth is significant and sustained.

A second recent change in living arrangements is a rise in group households. There has been a higher growth in group households relative to other forms since 2001. Table 1 provides an overview of the percentage change in the types of household between 2001 and 2011 and it highlights the large growth (22%) in group households over this time. Despite policy initiatives such as first home owner grants, (refer to the State Revenue Office website - first home owners, for details relating to subsidies available to Victorian first home buyers), tenure patterns have changed significantly between 2001 and 2011, with fewer younger and middle aged people owning their own homes. The rate of home ownership is currently sustained by older age groups (NHSC 2013).

Household Type	2001 %	2011 %	Per cent growth 2001 -2011
Couple family with children	34.3	32.4	8.7
Couple family no children	25.5	26.7	20.3
One-parent family	11.0	11.2	16.8
Other family household	1.3	1.3	10.0
Lone-person household	24	24.3	16.9
Group Household	3.9	4.1	22.3

Private Occupied Dwellings by Household Type 2001-2011
Source: National Housing Supply Council Data. (NHSC 2013)
Table 1

Fertility trends are an important consideration when investigating the shadow price of an additional bedroom. Changes in family size imply changing physical space requirements and can trigger relocations (Clark and Dieleman 1996: Rossi 1955). There is a large body of research that suggests the birth of a child increases a couple's likelihood of moving short distances to accommodate the expanding family. Additionally, couples tend to move in anticipation of childbearing (Kulu 2008). Clark and Huang (2003) identify the birth of a child as a major trigger to residential moves in the United Kingdom. The stimulus to move is predominantly driven by a need for living space conducive to family living, a bedroom for each child and adequate living spaces. (Clark and Huang 2003; Clark, Deurloo and Dieleman 1984). Furthermore, research by Dowling and Power (2012) explored the connections between familial and housing dynamics and identified that the desire/need for space, in particular more (and separate) bedrooms, was an important part of the Australian middle class identity when purchasing a property.

There has been considerable policy interest in the costs associated with raising children in Australia. In the context of an aging Australian population, a maternity payment, better known as the Baby Bonus, was designed to reduce the financial barriers to childbearing. It commenced in July 2004 as a universal payment of $3,000 but the subsidy has changed in size and structure since its introduction. A positive fertility effect of the Baby Bonus policy has been identified in the literature (Sinclair, Boymal, and De Silva 2012; Drago et al 2011; Lain et al 2009; Langridge et al 2010). In the policy period, there was found to be a particular increase in higher order births expanding family size. In reference to Table 1, although the household type of couples with children decreased proportionally, fertility rates increased between 2001 and 2011.

Housing is a major cost of family expansion. An expenditure survey approach (Percival and Harding 2007; Phillips 2013) has been used to measure changes in the differences in expenditure (including housing expenditure) of couple families of a similar standard of living conditional upon

the presence and number of children over this period. This approach, however, uses a narrow accounting cost perspective on changes in housing costs and does not take into account the costs of other housing attributes (such as proximity from the CBD) forgone in order to accommodate an expanding family. The expenditure survey approach may, therefore, understate changes in the costs of family friendly housing over time.

In summary, household forms have been changing in recent years and these changes have implications for the types of dwelling attributes demanded and thus their price. An assessment of the marginal price of a bedroom captures an important aspect of the housing market that has largely been ignored in previous studies.

METHODOLOGY

An hedonic specification is applied to the Melbourne metropolitan housing market using Victorian Valuer General data (1990–2010). This is a comprehensive data set recording all property sales and associated property characteristics. The data was cleaned and coded to include only Melbourne house and apartment sales. Melbourne is Australia's second largest city with a population in excess of 4 million. The Melbourne metropolitan area comprises 31 local government districts. Due to systemic data recording issues, data is missing for the LGAs Darebin and Cardinia. While key data was missing for these two districts, reducing the sample size, over 30 thousand observations remain with 29 of the local government districts available.

Following Rosen (1974), a two-stage estimation procedure is employed to calculate the implicit price of an additional bedroom. First, a hedonic price function is estimated by regressing the price of a house on its locational and structural characteristics. Second, the estimated coefficients are considered representative of prices for the attributes and are used to estimate fluctuations in a given bundle of attributes over time, ie: referencing a standardised house (Abelson, Joyeux, Milunovich and Chung 2005).

Two approaches are taken to identify whether there has been an increase in the marginal cost of an additional bedroom relative to other housing characteristics. One approach to assessing the temporal component is to apply a separate regression for each observed period (eg: year). Use of this indirect approach has the advantage of capturing any change in the contribution of an attribute to the property value over the period (Maurer 2004). This study focuses on the difference in the marginal cost of an additional bedroom in 2003 and 2008. These years are chosen to represent a year early in the decade which precedes the fertility policy, and one in the fertility policy period. This cross sectional approach is examined in Model 1. Temporal effects can also be dealt with by a direct method, which means including a dummy time variable for the observed period. To do this, a second model is applied to data from 1990-2010. It should be noted that the size of these coefficients will depend on the attributes included in the model; some omitted variable bias is inevitable in practice.

The hedonic pricing model takes the following simple general form:

$$\ln(p_h) = \alpha + \sum_{i=1}^{k} \beta_{h,i} X_{h,i} + \sum_{j=1}^{m} \delta_{h,i} Z_{h,j} + e_h, \quad e_h \sim N(0, \sigma^2), \qquad \text{Equation1}$$

where:

$\ln(p_h)$	=	the natural logarithm of the nominal price of the dwelling
$X_{h,i}$ and $Z_{h,j}$	=	structural dwelling characteristics, including the number of bedrooms and spatial characteristics

The influence of these attributes are denoted as $\beta_{h,i}$ and $\delta_{h,i}$ for the dwelling characteristics and spatial attributes, respectively. These coefficients represent marginal prices.

The explanatory variables may be summarised as follows:

Dwelling characteristics	Expected sign
Number of bedrooms (one to six)	+
Age of house (contract date, construction date)	_
Floor area (natural log m^2)	+
Land area (natural log m^2)	+
Dwelling type (house = 1; apartment = 0)	+
Spatial characteristics	
Distance to CBD	-
Distance to primary school	Non-linear
Distance to high school	Non-linear
Distance to amenities	Non-linear
Local Government Area (LGA) code	n/a

Model 1, a log linear model, captures the change in the marginal costs of the policy by referencing a sample year pre and post the policy, in this case 2003 and 2008. A second hedonic model is applied to the full data set, capturing sales data in Victoria from 1990 to 2010, as a robustness check. Model 2 is a log linear time dummy approach with a time trend variable and an interaction term capturing any additional premium on the number of bedrooms post-2004.

Model 1

Initially, to capture temporal effects using the indirect method, two hedonic price functions are estimated using representative sales data from 2003 and 2008. The implicit cost of an additional bedroom in a representative house in 2003 is estimated and compared to the implicit cost in 2008. The additional bedroom is the most relevant housing attribute associated with the changing cost of housing faced by expanding households.

This simple model serves two purposes. The first is to create a time-relevant snapshot of the housing market and mean housing characteristics faced by households over the period. Second, the model serves to estimate observed changes in the cost of an additional bedroom over the same period, while holding other fluctuations such as municipality premiums and locational factors constant, thus, estimating the costs of housing facing (in particular) growing households.

To measure the implicit price of an additional bedroom the following was first fit:

$$Ln(p_h) = \alpha + \sum_{i=1}^{39} \beta_{h,i} X_{h,i} + \sum_{j=1}^{5} (\delta]_{h,i} Z_{h,j} + [\gamma_{h,i} Z_{h,j}^2) + \sum_{m=1}^{13} \theta_{h,i} D_{h,m} + e_h,$$

$$e_h \sim N(0, \sigma^2),$$

Equation 2

where X represents the number of bedrooms (one to six), the age of the property, the log of the floor area, the log of the land area, whether the dwelling is an apartment or house and the LGA or municipality (premium).

The variables representing distance to schools, transport and amenities are captured by the set of variables *Z*. Following Boymal, De Silva and Liu (2013), this set of variables is specified as a polynomial of degree two as the influence of proximity to amenities on price is best summarised as being non-linear rather than strictly linear (Boymal et al 2013; Hill 2012). D is a matrix of period dummy variables such as the month and year of sale. The characteristic price approach is expanded in the second model where the model is fitted to the full data set, which includes a time-trend variable and the interaction of the post-policy period after 2004 and the number of bedrooms, thereby capturing any post-2004 bedroom premium that might be observed. This extension is presented as Model 2.

The coefficients represent the marginal prices of the various housing attributes. These coefficients are used to find a prediction given particular values of the regressors. This approach follows Anglin and Gençay (1996) where point-wise predictions are used to calculate how the predicted price will change as the number of bedrooms is increased *ceteris paribus* (refer to Anglin and Gençay (1996); Can (1992); Hill (2012); Lisi (2012) and Fillipova and Rehm (2009) for a discussion on functional form and model specification).

Comparison of Estimated Regression Coefficients for 2003 and 2008

The same semi-log hedonic regression is applied to sales data from 2003 and 2008 respectively and the coefficients are compared. The sample size differs across the two years, with the volume of sales in 2003 exceeding those in 2008. Locational premiums are captured by the LGA code variable. The model fit is good, capturing 81% (2003) and 86% (2008) of the variation in sale price respectively, although there is some evidence of omitted variable bias which can be a common problem in hedonic models of housing pricing (Hill 2012). The variable coefficients estimate discrete changes from the base case which is, in this instance, a unit with one bedroom located in the LGA of Banyule and sold in the month of January. The full sets of regression results from Model 1 are presented in the Appendix, in columns one and two of Table A.1. The coefficients relating to the number of bedrooms are presented in Table 2.

Variables	Model 1 (2003) Lprice	Model 1 (2008) lprice
Two bedrooms	0.0607***	0.103***
Three bedrooms	0.0232***	0.0645***
Four bedrooms	0.0216**	0.0541***
Five bedrooms	0.00631	0.0737***
Six bedrooms	–0.0315*	0.111***

***p<0.01, **p<0.05, *p<0.1.

Marginal Log of Price of an Additional Bedroom
Source: Authors
Table 2

The variables of particular interest in this paper are those relating to the cost of an additional bedroom. As stated, the reference case in both models is a dwelling with one bedroom located in the LGA of Banyule. The City of Banyule is located 20 km from the Melbourne CBD, covers an area of 60 sq km and has a population of 120,000. Full details of the distribution of observations across LGAs and regression results are presented in Appendix Table A.2. The coefficient estimates on each additional bedroom relative to a one-bedroom unit indicate the marginal price of each bedroom holding all else constant.

In 2008, the coefficients relating to each bedroom are larger and significant across all bedrooms (two to six) (see Table 2). This result suggests that additional bedrooms, particularly for large homes, were more highly valued in 2008. The coefficient on the fifth bedroom in 2003 is positive but insignificant. However, it is evident that this premium was positive and significant in 2008, indicating a positive premium on a fifth bedroom. The negative coefficient on the sixth bedroom in 2003 may be due to the floor area being held constant and thus adding bedrooms represents a reduction in space per room.

To capture the true living space demands and requirements of expanding households, the mean floor and land area per additional bedroom is calculated for both 2003 and 2008 and across the full data set. The mean floor and land area by bedroom reflect the reality that, as bedroom numbers increase; the total living space as measured by floor space tends to increase accordingly.

Table 3 demonstrates that there has been a small increase in the average size of a house sold in 2008 as both mean floor size and land size increase relative to 2003 (and relative to the mean across all years). To estimate the change in the premium paid for an additional bedroom over the period of analysis, coefficient results and mean values are used to calculate the price of a typical dwelling sold in 2003 and then again in 2008. To account for the incremental average increase in land and floor area by bedroom size, the mean area values listed for 2003 in Table 3 are applied to generate a dollar value for a standardised house in both years.

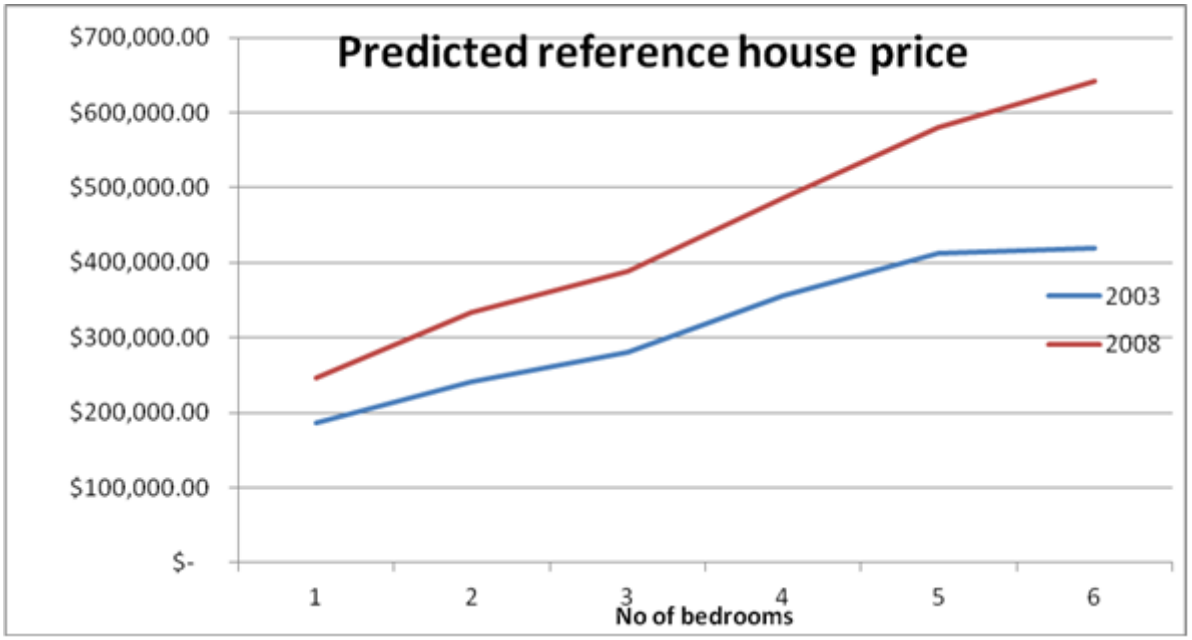
A comparative static approach holds constant all other hedonic coefficients to isolate the implicit price of an additional room. As can be deduced from Figure 1, households faced rising costs of housing in 2008. A household moving from an apartment to a house paid a 9.96% premium in 2008 as opposed to 4.87% in 2003. The highest marginal increase occurred in housing with a larger number of rooms. This could reflect the fertility-based transition motive, where families when moving generally make provision for the second child and, therefore, tend to transition on the arrival of a third child, reflected in the marginal cost of a fourth bedroom (Michielin and Mulder 2005).

The higher marginal cost for the fourth, fifth and sixth bedroom in 2008 may reflect the growth in higher order births noted in an earlier paper by Sinclair et al (2012). It could also reflect the rise in multigenerational living and group or share housing.

Table 4 shows the differential premium paid for a standard house between 2003 and 2008. The mean attributes are calculated on housing sales stock in 2003. However, if the housing stock is allowed to reflect mean floor and land size in 2008, the marginal cost of an additional bedroom dramatically increases in 2008. In 2008, the average house does not reduce land and floor size to compensate for additional bedrooms, so the marginal cost is significantly greater once the change in mean land and floor area is accounted for in the price estimation. In 2008, households wanting to purchase a dwelling faced rising costs of housing, in particular those demanding larger homes with three or more bedrooms appear to face the highest marginal cost of an additional bedroom.

Number of bedrooms	Mean land size (sqm) per bedroom 1990–2011	Mean floor area (sqm) per bedroom 1990–2011
One	445.86	73.70
Two	595.86	98.49
Three	699.24	131.63
Four	713.37	190.57
Five	765.09	242.26
Six	837.15	267.74
	Mean land size 2003	Mean floor area 2003
One	441.00	73.38
Two	583.48	99.30
Three	705.99	132.33
Four	757.02	190.91
Five	761.52	245.17
Six	917.65	267.31
	Mean land size 2008	Mean floor area 2008
One	470.97	76.01
Two	596.91	98.94
Three	710.03	134.61
Four	761.50	199.43
Five	812.55	262.36
Six	1147.93	356.96

Mean Land and Floor Space Per Additional Bedroom
Source: Authors
Table 3



Note: These figures are constructed by deriving the price effect from the hedonic coefficients of the OLS regression presented as Model 1 in Table A1. Mean land and floor size are adjusted as per mean values presented in Table 3 for 2003. The representative LGA is Banyule and the selling month is September; mean values are assigned for all other variables.

Predicted Nominal Prices for a Standardised House in Banyule 2003 and 2008: Model 1
Source: Authors
Figure 2

Marginal Cost of bedroom 2-6	2003: Mean attributes 2003	2008: Mean attributes 2003	2008: Mean attributes 2008	Differential Premium paid 2008 -2003 (same attributes)
1–2	$54,225	$89,411	$81,071	$35,186
2–3	$39,143	$53,200	$59,629	$14,057
3–4	$75,884	$98,665	$105,657	$22,781
4–5	$56,237*	$93,823	$105,984	$37,586
5–6	$7,853	$62,221	$170,988	$54,368

Note: These figures are constructed by deriving the price effect from the hedonic coefficients of the OLS regression presented as Model 1 in Table A.1. Mean land and floor size are adjusted as per mean values presented in Table 3 for 2003 and 2008 as specified. The representative LGA is Banyule and the selling month is September.
*This figure is derived from a non-significant coefficient.

Calculated Marginal Price of an Additional Bedroom: 2003 and 2008
Source: Authors - Calculations Using Mean Floor and Land Area Characteristics for 2003 and 2008
Table 4

Model 2

Although the above price-characterisation approach is useful and clearly illustrates that the marginal cost of a bedroom increased over the period to 2008, the base period regression could be run on a larger data set to increase the stability of the coefficients. To capture the marginal changes in the costs faced by growing households seeking additional living space, a post-2004 time dummy variable was interacted with the number of bedrooms and a time trend was added. The sample size is very large, capturing sales data for 785,205 properties over the period. The full regression results for Model 2 are presented in Table.A.1, however the specific co-efficient of interest capturing the post 2004 premium on an additional bedroom is presented in Table 5.

The regression coefficient on the number of bedrooms was significant and positive on all rooms except the sixth bedroom, which returned a negative coefficient. This may be due to the comparative static nature of the analysis wherein floor and land size are held constant. The time trend shows a positive trend in house price over the period. More importantly, the interaction term, which captures the post-2004 premium on the marginal cost of an additional bedroom, is positive and significant across all bedrooms, indicating growing households faced a significant cost premium post 2004, also the year the Baby Bonus policy was introduced.

The results indicate that homebuyers faced significant increase in the marginal cost for an additional bedroom in the period associated with a change in fertility and the average household size, in particular for properties with a higher number of bedrooms. This is consistent in both empirical approaches.

Number bedrooms	Model 2 1990-2011
Two bedrooms Three bedrooms Four bedrooms Five bedrooms Six bedrooms	0.0605*** 0.0652*** 0.0835*** 0.0507*** –0.0384***
Post 2004 premium on an additional bedroom	
One bed_04 Two bed_04 Three bed_04 Four bed_04 Five bed_04 Six bed_04	0.140*** 0.173*** 0.0771*** 0.0272*** 0.0745*** 0.174***
Time trend	0.0762***

Marginal Log of Price of an Additional Bedroom 1990-2011 and post 2004
Source: Authors - Estimates of the Hedonic Pricing Model for the Dependent Variable Natural Log of Dwelling Sale Price. Excerpt from Table 1A
Table 5

DISCUSSION AND CONCLUSION

This paper contextualises the additional costs of housing faced by expanding households. As families move through life stages such as marriage, age, and the presence of children, they re-evaluate the characteristics of their housing unit and changing physical space requirements can trigger relocations (Estiri 2012). Dowling and Power (2013) assert there is a cultural preference for separate bedrooms for household members and a strong desire for privacy within a household suggesting the marginal cost of an additional bedroom is an appropriate measure of the housing cost related to household expansion.

The results from the hedonic pricing model show that the price of an extra bedroom in an average Melbourne house significantly increased between 2003 and 2008. Increasing marginal costs are evident for growing households, as captured by rising shadow prices for the third, fourth and fifth bedrooms. An additional bedroom in an average house, in a median suburb of Melbourne, was estimated to have appreciated in price by approximately $14,000 for a third bedroom, $23,000 for a fourth, $37,000 for a fifth and $54,000 for a sixth. Assuming household size changes often trigger home relocations due to space constraints, expanding households faced higher housing costs in the late 2000's and this coincides with the small observed increase in average household size from 2005. Particularly notable is the increase in the cost of a two-bedroom home, which is conducive to family formation and the large marginal cost of a fourth and fifth bedroom.

This paper presents an alternative to an accounting cost perspective on changes in housing costs, being one that accounts for the costs of other housing attributes forgone in order to accommodate an expanding household and better capture changes in the costs of household expansion over time. An understanding of the true costs of housing faced by expanding households is a useful starting point for further research on the linkages between housing and fertility choice but also the rising prevalence and associated costs of multigenerational living forms.

Importantly, whilst the state of the housing market and housing affordability could provide an

explanation of why household size has increased, it could also be that increasing household size is causing higher marginal prices. No particular direction of causation is assumed here and indeed it is not necessary for this analysis. By specifically estimating the increase in the marginal cost of a bedroom, the analysis provides a more detailed and meaningful description of the market conditions expanding households have faced in recent times.

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Appendix A

Robust regression Variables	Model 1 (2003) Lprice	Model 1 (2008) Lprice	Model 2 (1990–2011) lprice
Two bedrooms	0.0607***	0.103***	0.0605***
Three bedrooms	0.0232***	0.0645***	0.0652***
Four bedrooms	0.0216**	0.0541***	0.0835***
Five bedrooms	0.00631	0.0737***	0.0507***
Six bedrooms	–0.0315*	0.111***	–0.0384***
Land area (Ln)	–0.00223	0.0500***	0.0252***
Floor area (Ln)	0.650***	0.628***	0.644***
Dwelling type (1 = house)	0.0487***	0.0996***	0.0647***
Age of house	0.000176***	0.00144***	–9.71e-05***
distance train	0.0106***	0.0120***	0.0108***
distance_train sqrd	–0.000664***	–0.000737***	–0.000594***
distance_activity centre	–0.00651***	–0.00871***	–0.00704***
distance_activity sqrd	0.000448***	0.000558***	0.000452***
distance_primary school	0.0354***	0.0282***	0.0277***
distance_primary sqrd	–0.00145***	–0.000544	–0.000902***
distance_high school	0.00226***	0.00118***	0.000152
distance_high sqrd	–4.33e-05***	–3.19e-05***	–2.78e-05***
distance_CBD	–0.0386***	–0.0457***	–0.0361***
distance_CBD sqrd	0.000459***	0.000542***	0.000405***
Bedrooms			
One bed_04			0.140***
Two bed_04			0.173***
Three bed_04			0.0771***
Four bed_04			0.0272***
Five bed_04			0.0745***
Six bed_04			0.174***
Constant	9.791***	9.944***	–143.1***
Observations	42,298	36,370	785,205
R-squared	0.814	0.860	0.854
df_m	58	58	66
F	3187	3854	69440
rss	1168	1065	46495

***p<0.01, **p<0.05, *p<0.1.

Note: For the sake of clarity the coefficients relating to the local government districts and time series characteristics are presented separately in table A.2. Given there was some evidence of heteroskedasticity (Breusch-Pagan test), a robust regression was run. See Can (1992, p462) for a discussion on estimation methods and appropriate estimation methods. Robust regression is a form of weighted and reweighted least squares regression.

OLS Estimates of the Hedonic Pricing Model for the Dependent Variable Natural Log of Dwelling Sale Price: 2003, 2008 and 1990–2011
Source: Authors
Table A1

	LGA Code	Freq.	Model 1 2003	Model 1 2008	Model 2
Banyule	303	28,714	0	0	0
Bayside	306	16,062	0.481***	0.634***	0.476***
Boroondara	307	23,443	0.328***	0.463***	0.356***
Brimbank	308	36,606	–0.264***	–0.345***	–0.284***
Casey	312	69,576	–0.0772***	–0.0270***	–0.0417***
Frankston	320	26,723	–0.0184*	0.00941	–0.0177***
Glen Eira	322	13,887	0.258***	0.309***	0.229***
Greater Dandenong	326	28,394	–0.0724***	0.0209**	–0.0832***
Hobsons Bay	331	23,538	–0.109***	–0.109***	–0.118***
Hume	333	40,909	–0.201***	–0.289***	–0.224***
Kingston	335	32,280	0.197***	0.258***	0.169***
Knox	336	43,833	0.0410***	0.0871***	0.0377***
Manningham	340	23,063	0.152***	0.208***	0.154***
Maribyrnong	341	20,966	–0.122***	–0.131***	–0.190***
Maroondah	342	28,026	0.0908***	0.131***	0.0769***
Melbourne	343	7,763	0.0183	–0.0231*	0.0643***
Melton	344	17,309	–0.269***	–0.314***	–0.297***
Monash	348	39,379	0.172***	0.265***	0.150***
Moonee Valley	349	21,609	0.0616***	0.0309***	0.0307***
Moreland	351	38,245	–0.0567***	–0.119***	–0.103***
Mornington Peninsula	352	41,068	0.164***	0.173***	0.156***
Nillumbik	356	14,243	0.119***	0.0772***	0.110***
Port Philip	358	17,850	0.293***	0.285***	0.312***
Stonnington	363	4,003	0.345***	0.508***	0.373***
Whitehorse	372	40,917	0.157***	0.233***	0.136***
Whilttlesea	373	31,000	–0.134***	–0.215***	–0.153***
Wyndham	375	33,067	–0.232***	–0.266***	–0.235***
Yarra	376	15,664	0.151***	0.148***	0.157***
Yarra Ranges	377	7,058	0.0624***	0.104***	0.0605***
	Total	785,205			

Frequency of Sales Observations and OLS Estimates: LGAs
Source: Authors
Table A2