KAMRA TAL-PERITI

to support members of the profession in achieving excellence in the practice of architecture and civil engineering in the interest of the community

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The Application of the Comparative Method

In the Valuation Office.

- Course A Thursday 24th October
- Course B Tuesday 29th October
- Course C Wednesday 30th October
- Course D Thursday 31st October
- Course E Wednesday 13th November

Programme

14.00 – 14.30 Registration/Welcome coffee/tea

14.30 – 15.30 Module I - Comparative Data in the Housing Market

15.30 – 16.15 Module II - Landed Property

16.15 – 16.30 Discussion

16.30 – 17.00 Coffee/Tea break

17.00 – 17.45 Module III - Rental Matters

17.45 – 18.05 Presentation by Perit Glynn Drago obo BOV

18.05 – 18.25 Presentation by Perit Karm Farrugia obo HSBC

18.25 – 19.10 Module IV - Financing Matters – Going from the technical to the strategic role

19.10 – 19.30 Discussion

Course co-ordinator:
Perit Denis Camilleri

VALUATION PRACTICE

The Application of the

COMPARATIVE METHOD

In the Valuation office

- Comparables
- Units of Comparison
- Zoning

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OCTOBER 2013

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OCTOBER 2013

MODULE NO I

Comparative Data in the Housing Market

Readings: 1-1 Real Estate Methods 1-2 Property Bubble
1-3 Dwelling Size 1-4 Floor Height condo value

METHODS OF VALUATION - 1

(1) Traditional valuation methods

- Comparable method;
- Profit method; - specialized valuations, look into audited accounts
- Development/residual method; - plots or sites
- Contractor's method/cost method; - specialised properties rarely sold – no rental evidence
- Multiple regression Method; and

See reading 1-1

METHODS OF VALUATION - 2

(2) Advanced valuation methods

- •Stepwise regression method
- •Artificial neural networks (ANNs);
- •Hedonic pricing method;
- •Spatial analaysis methods;
- •Fuzzy logic; and
- •Autoregressive integrated moving average (ARIMA)

See reading 1-1

COMPARATIVE METHOD

Appraisal experts widely believe that the sales comparison approach is the strongest approach only when a high number of representative sales have accurate and readily available data for the development of sales adjustments. It is most applicable to residential valuations, agricultural land and to some types of developable land.

This is not to say that the comparison method does not come to play in valuing commercial premises, as it does have a role of identifying units of comparison such as, rental value per sqm and the investment yield, key components for commercial valuations.

The drawback of the comparison method is that it is backward looking. valuers are to make credible adjustments reflecting current market circumstances and not just mimicking historic patterns.

AFFORDABLE PROPERTY RATES 1982 – 2013 (TABLE 1)

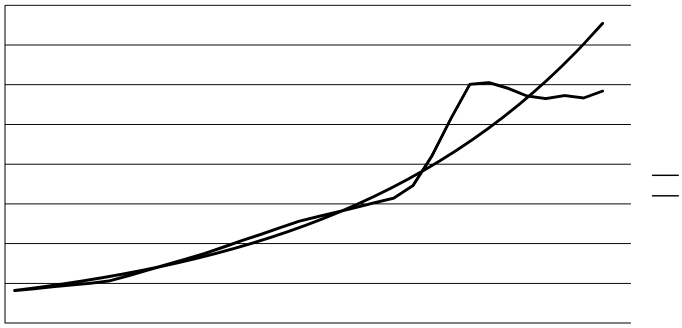
Locality	1982	1987	1992	1997	2002	2007	2012	2013	%growth rate Pa 1982-2013
Fgura/ Paola/ Zabbar	105	128	256	408	466	987	893	961	7.86%
M'scala	116	175	373	373	505	1001	881	886	6.83%
Mosta/ Naxxar	186	198	291	478	524	1242	1167	1196	6.99%
San Gwann	151	175	256	431	557	1092	962	1111	7.19%
Sliema inner prime	210	338	443	710	883	1373	1402	1361	6.34%
St. Julians	186	233	408	547	687	1321	1186	1261	6.72%
Swieqi	198	245	419	641	785	1473	1443	1399	7.08%
Malta	**163**	**212**	**349**	**512**	**629**	**1211**	**1134**	**1168**	**6.95%**
Trend	**164**	**235**	**336**	**480**	**687**	**982**	**1405**	**1509**	**7.42%**

Source DHI Periti in-house valuation

AFFORDABLE PROPERTY RATES 2002 – 2013 (TABLE 2)

Locality	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	% growth rate Pa 2002-2013
Fgura / Paola / Zabbar	466	575	678	762	928	987	961	948	971	906	893	961	5.46%
M'Scala	505	601	808	864	1032	1001	984	917	826	948	881	886	3.61%
Mosta / Naxxar	524	650	929	967	1149	1242	1176	1147	1154	1105	1167	1196	5.90%
San Gwann	557	666	752	969	1251	1092	1100	981	965	1026	962	1111	4.41%
Sliema inner prime	883	820	929	1316	1381	1373	1380	1322	1263	1398	1402	1361	4.33%
St. Julians	687	724	839	1267	1246	1321	1299	1327	1311	1286	1186	1261	5.19%
Swieqi	785	806	948	1058	1430	1473	1378	1367	1418	1348	1443	1399	5.50%
Malta	**629**	**692**	**841**	**1030**	**1202**	**1211**	**1183**	**1144**	**1130**	**1146**	**1134**	**1168**	**4.91%**
Trend	**687**	**738**	**793**	**851**	**915**	**982**	**1055**	**1055**	**1218**	**1308**	**1405**	**1509**	**7.34%**
Valletta	**610**	**959**		**1479**	**1410**	**1480**				**1964**	**1559**	**1634**	**7.27%**
Gozo	**432**					**857**	**841**	**913**	**988**	**853**	**903**	**916**	**6.60%**

MALTA AFFORDABLE PROPERTY IN €/M² OVER THE PAST 31 YEARS – FIGURE 1



Source: DHI Periti in-house valuations: Camilleri (2013) updated chart

Housing Bubble occurs if:
Doubling during a 5 – year period 2002 – 2007
50% increase over a 3 – year period 2002 – 2005

See reading 1-2

AFFORDABLE PROPERTY RATES €/M² FOR THE MALTESE ISLANDS OVER A 31 YEAR PERIOD (TABLE 3)

Locality	1982	1987	1992	1997	2002	2007	2012	2013
A	105	128	256	408	466	987	893	961
B	116	175	373	373	505	1001	881	886
C	186	198	291	478	524	1242	1167	1196
D	210	338	443	710	883	1373	1402	1361
E	186	233	408	547	687	1321	1186	1261
Malta	**163**	**212**	**349**	**512**	**629**	**1211**	**1134**	**1168**
Gozo	**-**	**-**	**-**	**-**	**432**	**857**	**903**	**941**

Source: DHI Periti

ZONE LOCALITIES

ZONE – A
Birżebbuġa, Fgura, , Gzira, Kalkara, Kirkop, Luqa Marsaxlokk, Msida, Mtarfa, Paola, Pietà, Qormi, Safi, Tarxien, Vittoriosa (Birgu), Qrendi, Senglea , St Paul's Bay, Santa Lucija, Vittoriosa (Birgu), Xghaira, Zabbar, Zebbug, Xghajra, Zurrieq

ZONE – B
Cospicua, Ghaxaq, Gudja, Ħamrun, Luqa, Marsa, Marsascala, Mqabba, Zejtun

ZONE – C
Attard, Balzan, Birkirkara, Dingli, Floriana, Iklin, Mellieha, Mgarr, Mosta, Naxxar, Rabat, San Gwann, Santa Venera, Siggiewi,

ZONE – D
Sliema, Swieqi, Mdina, Valletta,

ZONE – E
Lija Pembroke, St. Julian's, Ta'Xbiex

GOZO – these villages below conform
Fontana, Għajnsielem, Għarb, Għargħur, Għasri, Kercem, Munxar, Nadur, Qala, San Lawrenz, Sannat, Victoria, Xaghra Xewkija, Zebbug

SEAFRONT PROPERTY COMPARED WITH INTERNAL PROPERTY IN €/m²

	2006		2007		2008		2009		2010		2011		2012		2013	
Location	front	internal	front	internal	front	internal	front		front	internal	front	internal	front	internal	front	internal
M,skala	1473	1032	1696	1001	1413	985	1186	918	957	826	2307	948	-	881	802	886
Sliema	3246	1383	2602	1373	3296	1380	3428	1322	3311	1263	3086	1398	3706	1402	2381	1361
St Julians	1575	1245	2973	1322	2856	1299	2991	1327	2905	1311	4067	1286	1963	1186	2460	1261
Gozo						841	1484	913	988	988	1462	853	1548	903	459	916
Malta	2098	1220	2424	1232	2522	1221	1088	918	2391	1134	3153	1211	2835	1157	2420	1169

Source: DH Camilleri in-house valuations 2013

The Maltese Up market Housing Market.

The above average affordable Malta house rate of €1,134/sqm is to be compared with the up market residential developments which presently average out at €3,500/sqm, with the top end in the €5,000/sqm bracket, whilst the same up market Gozo rate averages out at €1,750/sqm. The range as noted in table 4 averages out at €2,835/sqm for Malta and at €1,548/sqm for Gozo.

72 Year Doubling Growth

The % growth rate for a value to double over a number of years is given by:

% growth = 72/No of years

Ex 1. – for an asset to double in value over a period of 10 years require an annual growth rate given by 72/10 years = 7.2 % p.a.

Ex. 2 – for an asset with a growth of 5%, it requires 72/5% = 14.4 years to double in value

GROWTH RATES OF MALTESE AFFORDABLE HOUSING

Year	1982	1987	1992	1997	2002
€/m²	163	212	349	512	629

Excel logest for $y = ab^x$ gives a = 69.12 b =1.0743 the b value indicates a 6.95% annual growth over the 20 year period

Excel growth calculates predicted growth values

Eg. @ year 2009 €965/m² @ year 2013 – €1483/m²

As compared to actual €1,211/m² & €1,168/m²

CONDIMINIUM Apartments

PortoMaso	€4,250/m²
Midi	€3,700/m²
Fort Cambridge	€3,500/m²
Pender Gardens (Street view)	€1,750/m²
(Piazza view)	€2,250/m²

These up-market developments may be compared to similar developments in London at €33,000/sqm, with Paris and Singapore at €20,000/sqm, and New York at €17,300/sqm. On the other hand Sydney comes in at €17,200/sqm, whilst Rome stands at €12,000 compared with Beijing commanding a €13,100/sqm price tag.

The wealthiest location is still Monaco at €45,900/sqm an increase of €900 from 2012. *(Source Knight Frank The Wealth report 2013)*

UPMARKET VILLA DEVELOPMENTS

*villa rates may vary from €3,500/m² - €2,000/m²
**exclusive palatial house of character may attract €5,000/m²+

Furthermore, the annual growth rates of these up market developments have been subjected to growth rates varying from 15% pa down to 9.5% pa, as compared to the comparable growth rate for affordable properties over the same 30-year period at 7.5% p.a.

Note that the luxury market over a long time span has been rising annually by an additional 2.5% compared to general prices. This confirms the higher growth rate for Maltese prime properties which in the long term can top a 9.5% growth rate, compared to the average property rate at 7.25%

A Tentative Valuation Model for Residential Premises - 1

A mathematical model used as an aid to intuition is more robust spreading forward the concept of fairness and tending to a more efficient system,

This is to be based on market rates per square metre for all localities in the Maltese Islands. A selected start is as noted in tables on affordable property rates for modern buildings with good quality of finish.

To arrive at the market value the floor area is to be calculated. The floor area according to KTP Valuation Standards 2012 Appendix A includes for thickness of the external walls, together with half the thickness of the party walls.

An extensive model had been created for the whole of Italy as undertaken by the Ministry of Economics and Finance (Italy) set up in 2001 (www.agenziaterritorio.it/?id=2158). This site gave extensive market data, capital and rental values giving a range of values at €/m² for residences, commercial outlets and offices for each province in Italy split up, into the various localities. Furthermore the state of repair is defined as optimal, normal or outdated.

A Tentative Valuation Model for Residential Premises - 2

Factors exist as noted in table 5 depending on location in the elevation of the block, together with size of the floor area. Some services are common to all residences, such that a 1 bedroomed apartment still has the water and electrical service with hot water explaining the higher factor for a smaller floor area. Factors also exist to the outside accommodation provided to cater for open and closed balconies, terraces, verandahs at penthouse level, backyards and gardens.

Table 6 provides factors for the quality of the residential area, depending on whether located in a quiet or noisy location. Table 7 then provides factors depending on the quality of finishings and servicing provided. Table 8 delves into the age of the premises together with its state of repair.

TABLE 5 - Factors Depending on Quality of Residential Areas

See reading 1-3 & 1-4

Factored Market Value Rate to Storey Height Location	
semi-basement	0.75
ground floor	0.9
ground floor maisonette type	1
first floor	0.95
intermediate floor	1
top floor	1.1
penthouse	1.25
Factored Market Value Rate to Floor Area:	
40sqm	1.25
50sqm	1.2
60sqm	1.15
75sqm	1.1
90sqm	1.05
100sqm	1
125sqm	0.95
150sqm	0.9
175sqm	0.85
200sqm	0.80
Factoring Floor Areas to Outside Accommodation	
backyards to apartments	0.15
gardens to villas up to block plan area - otherwise 0.02	0.1
open balconies	0.25
closed balconies and terraces	0.35
verandas up to floor area of penthouse - otherwise 0.15	0.5

MUTLTIPLE AGGRESSION ANALYSIS

- **An MRA model is essentially an equation used to predict the value of property, as the comparable approach to market valuation is essentially non-statistical**
- **Simplistic additive model structure is limited because it does not allow for the incorporation of elements, such as location, housing size, garage, whilst a multiplicative model is more effective**
- Market value = b0 X House size^{b1} X b2$^{\text{Central h}}$ X b3$^{\text{Garage}}$ X b4$^{\text{Location 1}}$ X b5$^{\text{Location 3}}$

Example 1

What is the market value of a modern penthouse in a good residential part of San Gwann, with a floor area of 50m^2, a front terrace of 75m^2 and a back terrace of 10m^2?

From Table 1 market value rate is given at	€1,111/m^2
For penthouse level factor to be applied 1.25	table 5
For a floor area of 50m^2 factor to be applied 1.2	table 5
For front terrace factor to be applied at 0.5 up to an area of 50m^2, with a 0.15 factor on the remaining 25m^2	table 5
For back terrace factor to applied at 0.35	table 5

Gross Floor Area:
50m^2 +50m^2 X 0.5+25m^2 X0.15+10m^2 X0.35 = 82m^2
Penthouse Market Rate: €1,111/m^2 X 1.25 X1.2
= €1,666.50/m^2
Market Value: €1,666.50/m^2 x 82m^2 = €136,653

TABLE 6 - Factors Depending on Location

Factors depending on quality of Residential Areas

Location	Quiet	Busy Road	Entertainment District	Small Industry	Sea Views	Country views
Factor	1	0.84	0.85	0.8	2.5 - 2	1.25 -1.5

TABLE 7 - Factors depending on standard Finishings
(for a recently completed residential premises)

Quality of Finish	Good	Excellent	Fairly Good	Poor
Factor*	1	1.10	0.85	0.75
No Lift	0.9	0.9	0.9	0.9

*exclusive of any A/C works, fireplaces, fitted kitchen and other building extras.

Example 2

What is the market value of a modern ground floor premises in Mosta located in a Small Industrial Estate with a floor area of 110m², a back garden of 35m² and a front terrace of 20m²?

From table 3 market value rate is given at €1,196/m²
For ground level premises factor to be applied at 0.9 table 5
For a floor area of 110m², factor to be applied at 1 table 5
For back garden factor to be applied at 0.1 table 5
For front terrace factor to be applied at 0.35 table 5
Location: Small Industry factor to be applied at 0.8 table 6

Gross Floor Area: $110m^2$ –$35m^2$X0.1+$20m^2$ X 0.35 = $120.5m^2$
Ground Floor market rate:€1,196/m^2 X 0.9 X 0.8 X1= €861/m^2
Market Value : €861/m^2 X $120.50m^2$ = €103,765

TABLE 8 -Factors Depending on Age of Residential Premises

(for houses of character age factor not applicable)

AGE - years	
0	1
10	0.94
20	0.90
30	0.87
40	0.85
50	0.83
60	0.81
70	0.78
80	0.77
100	0.75

Example 3

What is the value of the 3rd floor, 40-year old St Julians apartment in a block with no lift in an Entertainment district with fairly good finishings on an 85m² floor area and 5m² closed balcony?

From table 1 market value rate is given at:	€1,261/m2	
For a floor area of 85m² factor to be applied	1.05	table 5
For 3rd level factor to be applied	1.00	table 5
For closed balcony factor to be applied	0.35	table 5
For Entertainment District factor to be applied	0.85	table 6
For No Lift factor to be applied	0.90	table 7
For Fairly Good finishes factor to be applied	0.85	table 7
For 40 years age factor to be applied	0.85	table 8

Gross Floor Area: $85m^2 + 5m^2 \times 0.35$ = $86.75m^2$

3rd floor Market Rate: €1,261/m² X1.05 X 0.85 X 0.9 X0.85 X 0.85

= €732/m²

Market Value : €732/m² X 86.75m² = €63,500

EXAMPLE 4: Fort Cambridge Valuation

Apartment in question has Sliema open sea views from the front terrace, whilst Valletta views are from the rear bedroom area. This existing 3 bedroom apartment has an open plan living / dining fronting onto front sea terrace, together with an internal fitted kitchen to side. Additional accommodation includes for a guest's spare toilet together with a laundry room. An internal staircase opposite the fitted kitchen leads onto an overlying terrace airspace again with sea views and a pool construction.

Noting the above this top floor apartment on a freehold basis commanding views is estimated to have an open market value of:

1/	Habitable floor area	$167m^2$ @ €3,700m^2 X 1.2	= €741,480
2/	Terrace area with sea views	$25m^2$ @ €3,700/m^2 /2 X 1.2	= € 55,500
3/	Top terrace airspace	$180m^2$ @ €3,700/m^2 /3	= € 222,220
			€1,019,200

say **€1,000,000**

PROPERTY INDICES – TABLE 9

YEAR / SOURCE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
CBM*	100	87	86	82	97	87	99	117	127	140	142	168	201	216	235	
DHI**	100	106	112	117	123	130	146	163	180	197	214	234	255	274	294	
YEAR / SOURCE	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
CBM	267	276	299	314	341	386	465	510	529	534	520	494	499	506	516	
DHI	329	343	357	372	386	425	516	632	737	743	726	702	693	703	696	
NSO***							530	571	684	828	920	880	827	877	882	

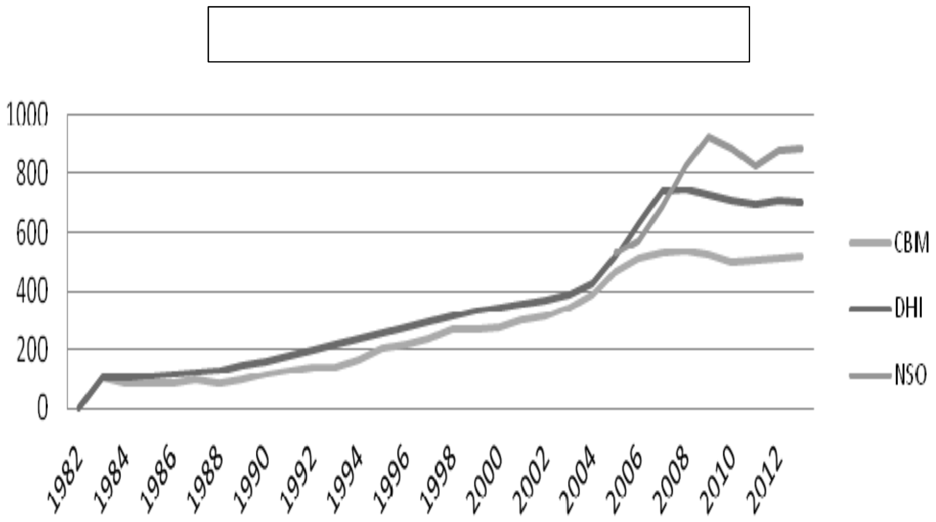
* CBM advertised newspaper listings

** DHI – In-house valuations

*** NSO Inland revenue property contract dealings

ALL PROPERTY RATES OVER 31 YEARS

FIGURE 2: Comparing CBM, DHI & NSO Property Bases



CBM PROPERTY PRICE INDEX – TABLE **10**

Period	Total	Apartments	Maisonettes	Terraced Houses	Others [1]
2000	100.0	100.0	100.0	100.0	100.0
2001	105.1	103.9	106.7	105.8	104.3
2002	114.2	113.0	115.3	114.0	110.6
2003	129.3	128.2	128.0	130.5	122.8
2004	155.6	157.0	155.4	151.1	153.8
2005	170.9	173.7	176.7	188.9	160.3
2006	177.0	178.3	187.0	196.2	175.0
2007	178.9	183.3	181.4	205.3	171.9
2008	174.1	172.7	181.4	201.5	173.7
2009	165.3	162.2	173.7	207.8	169.6
2010	167.1	166.4	171.8	199.4	178.5
2011	169.3	173.0	174.5	197.6	172.5
2012	170.1	172.5	173.5	185.5	172.4
2013 Q1	171.8	176.8	177.3	185.1	174.1

[1] Consists of town houses, houses of character and villas.

Source CBM Property price index

TABLE 11 – SECTORIAL AFFORDABLE PROPERTY INDEX OF THE MALTESE ISLANDS OVER THE PAST 31-YEAR PERIOD

Year / Zones	1982	1987	1992	1997	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
A	100	122	244	389	444	548	646	726	884	940	915	903	925	863	850	915
B	100	151	322	322	435	518	697	745	890	863	848	791	712	817	759	764
C	100	106	156	257	282	349	499	520	618	668	632	617	620	594	627	643
D	100	161	211	338	420	390	442	627	658	654	657	630	601	666	668	648
E	100	124	212	324	396	407	479	534	722	744	696	690	716	681	729	678
Malta	**100**	**130**	**214**	**314**	**386**	**425**	**516**	**632**	**737**	**743**	**726**	**702**	**693**	**703**	**696**	**717**
Gozo					**100**					**198**	**195**	**211**	**229**	**221**	**209**	**218**

Source: DHI Periti

ZONE LOCALITIES

ZONE – A
Birżebbuġa, Fgura, , Gzira, Kalkara, Kirkop, Luqa Marsaxlokk, Msida, Mtarfa, Paola, Pietà, Qormi, Safi, Tarxien, Vittoriosa (Birgu), Qrendi, Senglea , St Paul's Bay, Santa Lucija, Vittoriosa (Birgu), Xghaira, Zabbar, Zebbug, Xghajra, Zurrieq

ZONE – B
Cospicua, Ghaxaq, Gudja, Ħamrun, Luqa, Marsa, Marsascala, Mqabba, Zejtun

ZONE – C
Attard, Balzan, Birkirkara, Dingli, Floriana, Iklin, Mellieha, Mgarr, Mosta, Naxxar, Rabat, San Gwann, Santa Venera, Siggiewi,

ZONE – D
Sliema, Swieqi, Mdina, Valletta,

ZONE – E
Lija Pembroke, St. Julian's, Ta'Xbiex

GOZO – these villages below conform
Fontana, Għajnsielem, Għarb, Għargħur, Għasri, Kercem, Munxar, Nadur, Qala, San Lawrenz, Sannat, Victoria, Xaghra Xewkija, Zebbug

EXAMPLE No.5; residential apartment:-

What is the present-day value for the average Malta residential apartment as purchased in 2002 at €175,000? What would its value be if purchased in Fgura or Swieqi?

Malta residential property €175,000 X 717/386 X [1-(2013-2002) X 0.0065]

= €301,823 (72.5% increase)

Fgura residential property €175,000 X 915/444 X [1-(2013-2002) X 0.0065]

= €334,856 (91% increase)

Swieqi residential property €175,000 X 678/396 X [1-(2013-2002) X 0.0065]

= €278,198 (59% increase)

EXAMPLE No.6 – residential terraced house:-

What is the present day value for the average Malta terraced house purchased in 2007 at €300,000? What would its present value be if purchased in Mosta or M'Scala?

Malta residential property €300,000 X 717/743 X [1-(2013-2007) X 0.0065] X 1.15

= €268,802 (10.4% decrease)

Mosta residential property €300,000 X 643/668 X [1-(2013-2007) X 0.0065] X1.15

= €283,396 (10.6% decrease)

M'Scala residential property€300,000 X 759/863 X [1-(2013-2007) X 0.0065] X1.15

= €246,595 (17.8% decrease)

EXAMPLE No.7 – residential town house:-

What is the present day value for the average town house purchased in 2006 for €225,000? What would its present value be if purchased in Sliema or San Gwann?

Malta residential property €225,000 X 717/737 X [1-(2013-2006) X 0.0065]

= €203,243 (10% decrease)

Sliema residential property €225,000 X 648/658 X [1-(2013-2006) X 0.0065]

= €205,737 (8.6% decrease)

San Gwann residential property €225,000 X 643/618 X [1-(2013-2006) X 0.0065]

= €223,450 (2.85% decrease)

Reading 1 - 1

PRACTICE BRIEFING

Real estate appraisal: a review of valuation methods

Elli Pagourtzi and Vassilis Assimakopoulos
*School of Electrical and Computer Engineering,
National Technical University of Athens, Athens, Greece*
Thomas Hatzichristos
*School of Rural and Surveying Engineering,
National Technical University of Athens, Athens, Greece,
and*
Nick French
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Keywords *Market surveys, Real estate, Forecasting, Estimation, Assets valuation*

Abstract *The valuation of real estate is a central tenet for all businesses. Land and property are factors of production and, as with any other asset, the value of the land flows from the use to which it is put, and that in turn is dependent upon the demand (and supply) for the product that is produced. Valuation, in its simplest form, is the determination of the amount for which the property will transact on a particular date. However, there is a wide range of purposes for which valuations are required. These range from valuations for purchase and sale, transfer, tax assessment, expropriation, inheritance or estate settlement, investment and financing. The objective of the paper is to provide a brief overview of the methods used in real estate valuation. Valuation methods can be grouped as traditional and advanced. The traditional methods are regression models, comparable, cost, income, profit and contractor's method. The advanced methods are ANNs, hedonic pricing method, spatial analysis methods, fuzzy logic and ARIMA models.*

Introduction

Real property is defined as all the interests, benefits, rights and encumbrances inherent in the ownership of physical real estate, where real estate is the land together with all improvements that are permanently affixed to it and all appurtenances associated thereto.

The valuation of real estate is therefore required to provide a quantitive measure of the benefit and liabilities accruing from the ownership of the real estate. Valuations are required, and often carried out, by a number of different players in the marketplace. These may include:

- real estate agents;
- appraisers;
- assessors;
- mortgage lenders;
- brokers;
- property developers;

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- investors and fund managers;
- lenders;
- market researchers and analysts;
- shopping centre owners and operators; and
- other specialists and consultants.

This paper aims to examine the valuation of real estate prices, using prediction strategy based on selection of the best fitting model for use. The objective of the paper is to review the various methods used in real estate valuation.

The role of valuation

For any valuation to have validity it must produce an accurate estimate of the market price of the property. The model should therefore reflect the market culture and conditions at the time of the valuation. It should be remembered that the model should be a representation of the underlying fundamentals of the market. Thus, in the property market, what is often called a "valuation" is the best estimate of the trading price of the building.

In this context, the following convention is adopted:

- price is the actual exchange price in the marketplace;
- market value is an estimation of that price were the property to be sold in the market; and
- calculation of worth is used to assess the inherent worth to the individual or group of individuals.

In many property markets it is commonplace for the ownership of property to be separate from its use. Often the price of exchange will be the same whether the purchaser has investment or occupation in mind, but nonetheless the view of the two groups of bidders will be different. An investor will view worth as the discounted value of the rental stream produced by the asset, whereas the owner-occupier will see the asset as a factor of production and assign to it a worth derived from the property's contribution to the profits of the business. No doubt both groups of bidders will also be mindful of its potential resale price to a purchaser from the other group.

The concept of the worth of a property is most important in markets that are underdeveloped in terms of liquidity and the separation of ownership and use rights. Here most transactions are based on owner-occupiers' views of the worth of the property, i.e. the contribution it will make to business profit, as well as subjective issues such as status and feelings of security. Valuers, with hardly any transaction evidence, can only attempt to replicate these calculations of worth in arriving at an estimate of exchange price.

One of the paramount concerns of the valuation profession is the need to ensure that information presented to a client is clear and unambiguous. Not only should all parties understand the terminology used, it is also important that the client receives all other information that might be required to make a rational financial or investment decision. The latter point does not only concern the semantics of definitions of exchange price (see below), but must also address the issue of valuation methodology. Given that clients are themselves becoming more sophisticated in the way they determine whether to buy or sell property, then the pricing model used to assess the most likely exchange price should reflect their thought processes. This requires the valuer to better understand the client's requirements and leads to the adoption of more advanced valuation models which can reflect the increased level of data and information available.

Market value

A definition of value is an attempt to clarify the assumptions made in estimating the exchange price of a property if it were to be sold in the open market. These assumptions can include the nature of the legal interest, the physical condition of the building, the nature and timing of the market, and assumptions about possible purchasers in that market. Given that a compelling reason for using market value definitions is to ensure consistency in the process of valuation, it is important that there is a consistency of definition in all countries. For this reason, the International Valuation Standards Committee (IVSC) has set a "standard" to provide a common definition of market value. Market value is a representation of value in exchange, or the amount a property would bring if offered for sale in the open market at the date of valuation under circumstances that meet the requirements of the market value definition. In order to estimate market value, a valuer must first estimate the highest and best use, or most probable use. That use may be a continuation of a property's existing use or some alternative. These determinations are made from market evidence.

Market value is estimated through the application of valuation methods and procedures that reflect the nature of property and the circumstances under which the given property would most likely trade in the open market. Market value is defined for the purpose of the standards as follows:

> Market value is the estimated amount for which an asset should exchange on the date of valuation between a willing buyer and a willing seller in an arm's length transaction after proper marketing wherein the parties had each acted knowledgeably, prudently and without compulsion.

This paper reviews the various methods available to the valuer to estimate market value.

Methods

Each country will have a different culture and experience, which will determine the methods adopted for any particular valuation. The majority of all methods will rely upon some form of comparison to assess market value. This may be done, in its simplest form, by direct capital comparison or may rely upon a range of observations that allow the valuer to determine a regression model. Any such method is referred to in this paper as "traditional".

Other models or methods try to analyse the market by directly mimicking the thought processes of the players in the market in an attempt to estimate the point of exchange. These models tend to be more quantitive in method and will be referred to as "advanced".

For each method (or approach) that is described below, its theory is briefly explained together with an outline of how it is applied in the valuation process. The appropriate economic principles are also quoted with an explanation of how they apply to each method.

Methods can be grouped as follows:

(1) *Traditional valuation methods*:
- comparable method;
- investment/income method;
- profit method;
- development/residual method;
- contractor's method/cost method;
- multiple regression method; and
- stepwise regression method.

(2) *Advanced valuation methods*:
- artificial neural networks (ANNs);
- hedonic pricing method;
- spatial analysis methods;
- fuzzy logic; and
- autoregressive integrated moving average (ARIMA).

Traditional valuation methods

Comparable method

Sales comparison is the most widely used approach. The value of the property being appraised (called the subject property) is assumed to relate closely to the selling prices of similar properties within the same market area. The appraiser first selects several similar properties (comparables or simply comps) from among all the properties that have recently been sold. Since no two properties are identical the appraiser must adjust the selling price of each comparable to account for differences between the subject and the comparable, i.e. differences in size, age, quality of construction, selling date, surrounding neighbourhood, etc. The appraiser infers the current value of the subject from the adjusted sales prices of the comparables.

The sales comparison approach is heavily dependent on the availability, accuracy, completeness, and timeliness of sale transaction data. Information sources include government records, data vendors, and the appraiser's network of local contacts (e.g. brokers participating in transactions (Castle and Gilbert, 1998)).

Comparable sales analysis procedure may be viewed as a four-part process:

(1) For a given subject property, finding the most comparable sales.

(2) Adjusting the selling prices of the comparables to match the characteristics of the subject.

(3) Using the several estimates of value to arrive at an estimate of market value.

(4) Presenting the results in a report format suitable for viewing or printing.

The process of finding comparables utilizes "distance" to establish a measure of comparability between the subject and the comparable under consideration. It is computed by weighting the differences in characteristics between the subject and the comparable. The distance, D is calculated as follows (McCluskey *et al.*, 1997):

$$D = \sqrt[\lambda]{\sum_i [A_i(X_i - X_{si})]^\lambda + \sum_j [A_j \bar{\delta}(X_j, X_{sj})]^\lambda}, \tag{3}$$

where:

λ = Minkowski exponent lambda

A_i = weight associated with the ith continuous characteristic

X_i = value of the ith characteristic in the sale property

X_{si} = value of ith characteristic in subject property

$\sum_i$ = summation of terms of i characteristics

A_j = weight associated with the jth categorical characteristic

X_j = value of jth characteristic in sale property

X_{sj} = value of jth characteristic in subject property

$\sum_j$ = summation of terms of j characteristics

$\delta(a, b)$ = inverse delta function (0, if $a = b$; 1, if $a \neq \delta b$).

For each comparable property the sales price is adjusted to the subject property as follows:

Adjusted sales price = sales price − (comparable MRA − subject MRA).

Given the several comparable sales, several adjusted selling prices are obtained. A weighted estimate is formed as follows:

$$\text{Weighted estimate} = \sum_{i=1}^{n} \frac{W_i}{W} ASP_i, \tag{4}$$

where the weight for the comparable is:

$$i = W_i = \frac{1}{(D/2)^2 + D_j^2 + [2D(|ASP_i - SP_i|/SP_i)]^2}, \tag{5}$$

$$W = \sum_{i=1}^{n} W_i, \quad (6)$$

where:
ASP_i = adjusted sale price for comparable i
SP_i = sale price of comparable I
D_i = distance for comparable I
D = max of D_i.

Thus the weighted estimate of value places more emphasis on properties, which are most like (smaller distances) the subject property and have the smaller adjustments to the selling price. The comparables with the lowest distance are selected. In calculating the distance the variables are allocated a factor weight (McCluskey and Borst, 1997). The weighting is used to balance the effect of variables according to the magnitude of the variable itself, so that a variable with larger numerical size has a smaller weight. This process of computing several comparable sales estimates of value, a weighted estimate of value and an MRA (multi regression analysis) estimate of value yields, in the case of five comparable sales, seven estimates of value.

Investment/income capitalisation method

At its simplest level, the comparable model can be used to determine capital value directly. However, moving from sub-markets where there is a high degree of similarity (for example, residential markets), the way in which comparison can be utilised needs to be modified.

In the investment market, for example, direct capital comparison is rarely appropriate because the degree of heterogeneity is much higher. As such, the comparison needs to be broken down further to look at rental (on a *pro-rata* basis) and the initial yield achieved on sale. This distinction between the rental and the yield reflects an interesting interaction between two sub-markets, the occupational market and the investment market. At its simplest level, property can either be owned and occupied by the same party (owner-occupied), or the owner can choose to pass the right of occupation to a third party by letting the property. The tenant will then pay the owner (the landlord) a rent to represent the (normal) annual value of the property to the tenant. The level of rent is determined by the supply of, and demand for, that type of property in the market. The rent also represents the return or interest on the money invested in the property by the owner. It is the remuneration for the giving up of the use of the property. This rental income is simply a cash flow and as such the value of the rented property may be determined by the present value of the predicted cash flow.

Similarly, it is possible to determine a gross rent multiplier by analysing other previous sales. Investors can be determined to be paying "*x*" times the rent for a particular type of property. The higher the multiplier the higher the market value, and this in turn reflects the greater attractiveness of the subject property. Thus, valuers decapitalise recent comparable sales and apply the derived multiplier to the rent of the subject property. The investment method is a method of simple comparison. It does not attempt to analyse the worth of the property investment from first principles.

Profits method

In the section above, the investment method is shown to be a method where valuation methodology has moved away from modelling the thought processes of the players in the market, and instead assesses the market value of a subject property by reference to observed recent transactions of similar properties in the same area. It no longer looks at the fundamentals; the original reasons why the purchasers might be willing to buy at a certain price for such assets in the market.

However, if there are insufficient sales to determine a comparable value and if there is no rent produced because the property is in owner-occupation, then the valuer must determine the value by returning to a detailed market analysis. For instance, the market value of a hotel in owner-occupation will be dependent on the potential cash flow to be derived from ownership. That cash flow will be determined by the number of bedrooms in the hotel, the room rate and the average occupancy rate for the year. In other words, property is simply viewed as a unit of production and it is the valuer's role to assess the economic rent for the property from first principles. This is calculated by assessing the potential revenue to be expected each year from the hotel, and deducting all other costs of a prudent hotelier in realising that cash flow. These costs will include direct costs such as catering, laundry and service. In addition, allowances will need to be made for the remuneration of the hotelier, interest on money borrowed to run the hotel and a return on capital for any equity tied up in the business. Having calculated the liabilities these are deducted from the revenue figure and the residue will be an estimation of the economic rent for the property. The capital value can then be derived by multiplying the annual rent by an appropriate multiplier.

This process reverts to a fundamental analysis of the worth of the property to the business. The economic rent is a derivative of the supply and demand for the final product, in this example, the hotel rooms. The same principle will apply to any type of property where the market value of the property is intrinsically linked to the business carried out within that property. Other examples will therefore include restaurants, leisure centres, cinemas, theatres, etc.

Development/residual method

The properties under estimation are plots or sites that can be developed. The best method for estimating site value is through comparable vacant land sales. The sales should be reduced to appropriate units of comparison. The value of the land or site should be estimated as if the site were vacant and available for its highest and best use. Each comparable sale should be described. As a minimum, the description must include the following data:

- location;
- grantor;
- grantee;
- recording data;
- date;
- sale price;
- financing;
- units of comparison;
- lot dimensions;
- configuration and size;
- physical and topographical characteristics;
- zoning, utilities; and
- environmental influences.

This analysis of understanding the market value of the land and property to the business can be extended to include the valuation of development property. If one views the process of (re)development as a business, it is possible to assess the market value of land and buildings in their existing form as part of that process. Development occurs where the current use of land and buildings is not the highest and best. By spending money redeveloping the site, it is possible to release latent value, as the market value of the land is increased due to the demand for the new use commanding a higher price than the previous use. By viewing development in this way, it can be seen that the residual method of valuation is very similar to the profits method.

With the residual method, the valuer assesses the market value of the land in a redeveloped form (either by comparison or by the investment method) and deducts from this gross development value all costs that will be incurred in putting the property into the form that will command that price. These costs will include demolition of the existing building (if not already a cleared site), infrastructure works, construction costs, professional fees, finance costs and a remuneration for undertaking the risk of development (developer's profit). By deducting these liabilities from the final market value, a residue is produced. This residue represents the maximum capital expenditure for buying the land. It will therefore include all costs of purchase (taxation, legal fees, professional fees and finance). The net residual land value is determined by allowing for these additional land costs. It can be seen therefore that the residual land value is, as with any economic rent, dependent upon the supply and demand of the finished product, the developed property. The greater the demand for the finished property, the higher the gross development value, and if costs remain relatively static, the higher the market value of the land in its original state.

Contractor's/cost method

A further way in which it is possible to estimate the market value of land and property is the contractor's method or the replacement cost method. If the property being valued is so specialised that properties of that nature are rarely sold on the open market, it will be effectively impossible to assess its value by reference to comparable sales of similar properties. Similarly, if there is no rental produced, the investment method will also be inappropriate. The profits method could be applied if the property is intrinsically linked to the business carried out in the property, however, where that business is one of production (rather than service) it is difficult to determine the contribution of the property to the overall usage. The plant and machinery contained within are likely to have a greater value to the business than the structure containing them. Thus, once again, the valuer must revert to understanding the thought process of the user of the building. This can be illustrated by reference to a property such as an oil refinery. Here the nature of the business is so specialised that there are no comparisons, the property would be owner-occupied so there is no rental and the plant and the machinery will be the important elements contributing to the value of the business. Thus, the owner of the building will simply assess the market value of the building by reference to its replacement cost. How much would it cost to replace the property, if the business were deprived of its use? In simple terms, market value will equate to reconstruction costs. The valuer will assess the market value of the raw land (by reference to comparable land values in an appropriate alternative use), add to this value the cost of rebuilding a new building which could perform the function of the existing structure, and from this then make subjective adjustments to allow for the obsolescence and depreciation of the existing building relative to the new hypothetical unit. It is reasonable to assume that this mirrors the thought process of the owner-occupier and thus should be viewed as a valid and rational method of valuation.

It is interesting that in countries where property investment is less prevalent and where owner-occupation is the favoured method of property utilisation, then it is not only specialised properties which are valued by the contractor's method. If there is no investment market (i.e. properties will only exchange between owner-occupiers in the market) then the price of exchange will reflect the "bottom line" cost to the purchaser. This bottom line will be the cost that will need to be incurred for a new build relative to the existing property that is on the market. There will be a strong correlation between price and cost. However, if the occupation market is dominated by companies renting, and there is a degree of scarcity in the market, then price will be determined not by cost, but by the supply and demand characteristics of the occupational market. In such a case, regardless of the nature of the property, the investment method will dominate as the favoured valuation model.

Multiple regression method

The general multiple linear regression models is:

$$_i = \beta_0 + \beta_1 X_{1,\,i} + \ldots + \beta_k X_{k,\,i} + \epsilon_I, \tag{1}$$

where Y_i, $X_{1,i}, \ldots, X_{k,i}$ represent the ith observations of each of the variables $Y_i, X_1, \ldots, X_k$ respectively, β_0, $\beta_1, \ldots, \beta_k$ are fixed (but unknown) parameters and ϵ_i is a random variable that is normally distributed with mean zero and having a variance σ_ϵ^2.

There are several assumptions made about X_i and ϵ_i which are important:

- The explanatory variables $X_1, \ldots, X_k$ take values which are assumed to be either fixed numbers (measured without error), or they are random but uncorrelated with the error terms ϵ_i. In either case, the values of $Xj(j = 1, 2, \ldots, k)$ must not be all the same.
- The error terms ϵ_i are uncorrelated with one another.
- The error terms ϵ_i all have mean zero and variance σ_ϵ^2, and have a normal distribution (Makridakis *et al.*, 1998).

There is an example of regression analysis in real estate (Wolverton, 1997). The data for this example consisted of 56 residential, mountainside view lots located in Tucson, Arizona, on sale over the 1989-1991 period. The data are restricted to a relatively small geographic area to control for variation in household income and other exogenous price influences. All the sale properties are located within the same public school district, subject to the same governmental jurisdiction and property tax rates, and are equally distant from major employment nodes.

The characteristic variables of the model are:

- quality of city view (VIEW) was measured by metrically scaling the width of each lot's angle of city view panorama, adjusted for blockage or potential blockage from nearby homes;
- lot size (SIZE) was taken from recorded plots;
- a dummy variable (DEV) was coded as one for seven of the lots in the data set involved steep terrain and consequently high-expected expenditures for site fill and building foundations, and zero otherwise; and
- variables that describe 21 sales which occurred in 1988, 11 in 1989, 19 in 1990, and five in 1991.

The example of the functional form of diminishing marginal price deals with the price per square foot and the second subsection deals with the price per degree of included angle of view. As a first step in the analysis of diminishing marginal price per square foot, lot price per square foot (PSF) was regressed on lot developability (DEV), lot size (SIZE) measured in thousands of square feet, city view (VIEW), and year of sale (YR 1989, YR 1990 and YR 1991) with 1988 as the base year (referred to herein as the "naïve" model). This first regression model demonstrates that these variables account for most of the variability in lot price per square foot (adj. $R^2 = 0.77$), and that DEV, VIEW and SIZE are all significant determinants of price in this sub-market, with p values of 0.001 or better.

The estimation model is depicted by:

$$P_{SF} = \beta_0 + \beta_i(DEV) + \beta_2(VIEW) + \beta_3(YR1989)$$

$$+\beta_4(YR1990) + \beta_5(YR1991) + \delta. \quad (2)$$

Stepwise regression method

Stepwise regression is a method which can be used to help sort out the relevant explanatory variables from a set of candidate explanatory variables when the number of explanatory variables is too large to allow all possible regression models to be computed.

One of the main kinds of stepwise regression in use today is called "stepwise forward-with- a-backward-look regression" and is explained below:

- *Step 1*: Find the best single variable (X_{1*}).
- *Step 2*: Find the best pair of variables (Y_{1*} together with one of the remaining explanatory variables – call it X_{2*}).
- *Step 3*: Find the best triple of explanatory variables (X_{1*}, X_{2*} plus one of the remaining explanatory variables – call the new one X_{3*}).
- *Step 4*: From this step on, the procedure checks to see if any of the earlier introduced variables might conceivably have to be removed. For example, the regression of Y on X_{2*} and X_{3*} might give better R^2 results than if all three variables X_{1*}, X_{2*} and X_{3*} had been included. At step 2, the best pair of explanatory variables had to include X_{1*}, by step 3, X_{2*} and X_{3*} could actually be superior to all three variables.
- *Step 5*: The process of looking for the next best explanatory variable to include, and checking to see if a previously included variable should be removed, is continued until certain criteria are satisfied. For example, in running a stepwise regression program, the user is asked to enter two "tail" probabilities:

  the probability, P_1, to "enter" a variable; and

  the probability, P_2, to "remove" a variable.

When it is no longer possible to find any new variable that contributes at the P_1 level to the R^2 value, or if no variable needs to be removed at the P_2 level, then the iterative procedure stops (Makridakis *et al.*, 1998).

An example about stepwise regression is presented. In the current example, a model is performed on some 2,405 cottages sold in the Quebec Urban Community (QUC) from January 1993 to January 1997. Cottages present the advantage of being spread all over the QUC, as opposed to bungalows (one-story, detached, houses) and to condominium units, found mainly in suburban areas in the former case and in central neighbourhoods in the latter. Sale prices of sampled cottages range from $50,000 to $250,000, with mean price standing at $123,183. Many attributes are available to describe these transactions. They can be grouped as follows:

- transaction attributes (mainly sale price, the dependent variable);
- property specifics (66 attributes in the initial data set; 22 selected during stepwise regression analysis – models A to D);
- local taxation attributes (two available; two selected by the model – models A to D);
- neighbourhood attributes (34 relative attributes – models C and D);
- proximity attributes designed at capturing externalities (19 initial variables – models B to D); and
- travel accessibility measured on the street network (15 provided – model D).

Following a five-step approach, property specifics are first introduced in the model; proximity and neighbourhood attributes are then successively added on. Finally, factor analyses are performed on each set of access and census variables, thereby reducing to six principal components an array of 49 individual attributes. Substituting the resulting factors for the initial descriptors leads to high model performances, and controlled colinearity, although remaining spatial autocorrelation is still detected in the residuals (Des Rosiers *et al.*, 2000).

Advanced valuation methods

Artificial neural networks (ANNs)

Artificial neural network models have been offered as a possible solution to many problems in real estate valuation. An artificial neural network model must first be trained from a set of data and the model is then utilized to estimate the prices of new properties from the same market. Neural networks are artificial intelligence models originally designed to replicate the human brain's learning processes.

These models have three primary components:

(1) the input data layer;

(2) the hidden layer(s), commonly referred to as the "black box"; and

(3) the output measure(s) layer, the estimated property value(s).

The hidden layer(s) contain two processes: the weighted summation functions; and the transformation functions. Both of these functions relate the values from the input data (e.g. the property attributes: number of bathrooms; age of house; lot size; basement area; total area; number of fireplaces; number of garages) to the output measures (the sales price). The weighted summation function typically used in a feed-forward/back propagation neural network model is:

$$Y_j = \sum_{j}^{n} X_i W_{ij}, \tag{7}$$

where X_i is the input values and W_{ij} is the weights assigned to the input values for each of the j hidden layer nodes. A transformation function then relates the summation value(s) of the hidden layer(s) to the output variable value(s) or Y_j. This transformation function can be of many different forms: linear functions, linear threshold functions, step linear functions, sigmoid functions or Gaussian functions. Most software products utilize a regular sigmoid transformation function such as:

$$Y_T = \frac{1}{1 + e^{-y}}. \tag{8}$$

This function is preferred due to its non-linearity, continuity, monotonicity, and continual differentiability properties (Borst, 1992; Trippi and Turban, 1993).

There is research about three artificial neural networks for estimating the value of a random sample of "normal" residential properties and a sample of outlier properties. The data used in this research consist of 288 single-family residential properties that were sold in Fort Collins, Colorado, USA from November 1993 to January 1994.

The variables that determine value were the number of bathrooms, the age of the house, the lot size, the finished interior square footage of the house, whether there was a basement, the number of fireplaces, and the size of the garage. The log of the property sales price was used as the output layer for the artificial neural network model.

Outlier properties were determined as properties that possessed a z-score greater than 2.0. A z-score was measured by subtracting the property price from the average price of the houses in the sample and dividing by the sample standard deviation. A total of 17 outlier properties were identified and separated into an "outlier" holdout sample, leaving 271 properties in the "normal properties" data set. The remaining 271 properties were sorted by price and every fourth property was separated out into a "normal" holdout sample, leaving 204 properties to be the training sample for creating the artificial neural networks.

The model with the optimal number of hidden layer nodes would possess the minimum mean absolute prediction error and the maximum number of houses within a 5 per cent absolute prediction error of the actual sales price. Six hidden layer nodes were found to be the optimal number of nodes within the hidden layer for the three artificial neural networks.

Hedonic pricing models

The theory of hedonic price functions provides a framework for the analysis of differentiated goods like housing units, whose individual features do not have observable market prices. A differentiated product can be represented as a vector of characteristics with the market price dependent upon the set of features. The market price of the product implicitly reveals the hedonic price function relating characteristics to prices. The traditional use of hedonic estimation in housing studies has been for the purpose of making inferences about non-observable values of different attributes like air quality, airport noise, commuter access (railway, subway or highway) and neighbourhood amenities (Janssen *et al.*, 2001).

Spatial analysis methods

While GIS can improve the measurement of location and access variables, namely by resorting to time, rather than mere Euclidean distances, their analytical capabilities are greatly enhanced where spatial statistics methods are integrated (Anselin and Getis, 1992; Griffith, 1993; Zhang and Griffith, 1993; Theriault and Des Rosiers, 1995; Levine, 1996). Indeed, procedures such as spatial pattern analysis and autocorrelation analysis (Odland, 1988; Cressie, 1993; Ord and Getis, 1995; Tiefelsdorf and Boots, 1997) as well as variography and Kriging techniques (Dubin, 1992; Panatier, 1996) can help detecting additional neighbourhood factors that must be considered to explain market variability, as it is described below.

An alternative to the establishment of fixed neighbourhoods or composite sub markets involves a more rigorous spatial analysis of property prices in terms of developing terrain of surface models using spatial interpolation. The spatial interpolation techniques use a set of data based on discrete points for sub-areas, then determine a function that will best represent the whole surface which can then be used to predict values at other points or sub-areas. Chou (1997) states the two fundamental assumptions underlying spatial interpolation. First, the surface of the z-variable is continuous; therefore the data value at any location can be estimated if sufficient information about the surface is given. Second, an implicit assumption is that the z-variable is spatially dependent; in other words the interpolation of the variable value can be extracted from the given spatial distribution because the value at any specific location is related to the values of surrounding locations. Numerous algorithms for point interpolation have been developed; however, the selection of the appropriate algorithm depends largely on the type of data, the degree of accuracy required and the amount of computational effort (Lam, 1983). According to Lam (1983) the point interpolation methods can be classified as either exact or approximate methods.

Within a GIS framework the use of surface response analysis techniques has been shown to provide a three-dimensional visualization of the value of location as it varies geographically. While research in this area has been limited, the work which has been carried out has contributed to a better understanding of the measurement of location effects. Research into triangulated irregular networks (TINs) by LaRose (1988) demonstrated the potential of this approach to predictive modelling. This research was also interesting from the perspective that a global TIN produced better results that a TIN which was based on a stratified subset. In further developing this line of research Des Rosiers and Theriault (1992) investigated the use of isovalue plots and three-dimensional models; Wyatt (1995) utilized three-dimensional images integrated with network models; Gallimore *et al.* (1996) investigated the use of MRA generated residuals (with no location variables) in building a response surface which could then be used to adjust for the under- or over-valuation of the property. A perceived problem with this approach is that the adjustment factor used was based on the error for each property; while this worked well with properties having known sale prices, its validity would need to be tested in relation to unsold properties.

Fuzzy logic

Classic Boolean logic is binary, that is a certain element is true or false, an object belongs to a set or it does not. Fuzzy logic, introduced by Zadeh in 1965, permits the notion of nuance. The key to Zadeh's idea is to represent the similarity a point shares with each group with a function (termed the membership function) whose values (called memberships) are between $0 < m < 1$. Each point will have a membership in every group, memberships close to unity signify a high degree of similarity between the point and a group, while membership close to zero implies little similarity between the point and that group. Additionally, the sum of the memberships for each point must be unity.

Every continuous math function can be approximated by a fuzzy set.

Several types of membership functions can be utilized. The membership function reflects the knowledge for the specific object or event.

Another critical step in the fuzzy systems methodological approach is the definition of the rules, which connect the input with the output. These rules are based on the form "if … then … and". The knowledge in a problem-solving area can be represented by a number of rules. For example, if the output set "value: is comprised by two subsets called: 'low' and 'high'," two rules could be:

(1) If the distance is small then value is low.
(2) If the distance is great then value is high.

In order to solve a problem with a knowledge-based fuzzy system it is necessary to describe and process the influencing factors in fuzzy terms and provide the result of this processing in a usable form. The basic elements of a knowledge-based fuzzy system are:

- fuzzification;
- knowledge base;
- processing; and
- defuzzification.

The use of fuzzy logic for the analysis and the modelling of real estate could be a powerful tool in modern planning, as is pointed out by many researchers (Bagnoli and Smith, 1998; Gold, 1995; Byrne, 1994). The most important advantages of fuzzy modelling are:

- It is a more realistic approach through the use of linguistic variables instead of numbers.
- Hierarchical ranking of the objects (e.g. buildings, lots) and not an inclusion – exclusion list.
- Fewer repetitions of the model.

Autoregressive integrated moving average (ARIMA)

Autoregressive (AR) models can be effectively coupled with moving average (MA) models to form a general and useful class of time series models called autoregressive moving average (ARMA) models. However, they can only be used when the data are stationary. This class of models can be extended to non-stationary series by allowing differencing of the data series. These are called autoregressive integrated moving average (ARIMA) models. Box and Jenkins (1970) popularized ARIMA models.

There are a huge variety of ARIMA models. The general non-seasonal model is known as ARIMA (p, d, q):

AR: p = order of the autoregressive part.

I: d = degree of first differencing involved.

MA: q = order of the moving average part (Makridakis *et al.*, 1998).

There is some research that applies the Box-Jenkins methodology – ARIMA model to the study of Hong Kong's real estate prices (Tse, 1997). This example shows how the office and industrial property prices in Hong Kong can be fitted into the ARIMA equation. They used quarterly data in the period 1980Q1-1995Q2 (the year is separated in four quarters Q1, Q2, Q3, Q4) which contained 59 observations. The estimated equations have been used to forecast for the next three quarters. It is in any case difficult to identify the most appropriate proxy for the price index in the real estate market, since this heterogeneous sector includes different types and classes of building, and demand for them is generated across all sectors of the economy. Above all Hong Kong's properties are more homogeneous since multi-storey development has remained predominant in the real estate market.

The general form of the ARIMA model can be written as:

$$\phi(B)(1-B)^d Y_t = \theta(B)_{\epsilon_t}. \tag{9}$$

where B represents the back shift operator such that $BY_t = Y_{t+1}$, Y_t is the value of the time series observation at time t, ϵ_t is a series of random shocks which are assumed to be independently, normally distributed with zero mean and variance and d represents the order of difference. If a series is stationary, then $d = 0$. In equation (10), $\phi(B)$ is a polynomial of order p in the back shift operator B, which is defined as:

$$\phi(B) = 1 - \sum_{i=1}^{p} \phi_i B^i. \tag{10}$$

Similarly, $\phi(B)$ is defined to be a polynomial of order q in B, such that:

$$\theta(B) = 1 - \sum_{i=1}^{q} \theta_i B^i. \tag{11}$$

This is the only valuation method that depends on time variables. The ARIMA model is essentially an approach to economic forecasting based on time-series data (Dickey and Fuller, 1981; Granger and Newbold, 1974; Tse, 1996).

Conclusions

In this paper we have reviewed the methods that have been used for estimating real estate property's value. The existing European (UK) and North American (US) literature considers that the comparable method is accurate and reliable estimated method. Many researchers have their reservations about method's reliability because of the subjectivity of the key variable choice. In cases where there is lack of data we can use the comparable method. The surveyor imprints the property market in order to estimate the value of the property. He or she has to determine the comparative set of properties and recognizes the key variables. This method allows us to focus on selection, evaluation and registration of the value elements that is very important in appraisal.

Other methodologies that are also presented in this paper can resolve the problem of estimating the value of properties as a possibility in this regard. For example, the resulting regression coefficients provide estimates of the value of individual property features. This offers a scientific basis for the price adjustments and does not rely on the judgment and experience, or inexperience, of the appraiser or agent. Regression analysis can also handle many more comparables than the few generally used in comparative market analyses performed by real estate agents or accredited appraisers.

A dilemma in social science is that one often does not know which the appropriate model is. The procedure then is to reason through the issues, consult the literature, consider alternatives, choose a model, perform the analysis, and study the results. If the results do not give cause to refute the model, appear reasonable and logical, and in agreement with accepted beliefs, the model is regarded as appropriate. We proceed according these principles, paying particular attention to the following two issues (Janssen *et al.*, 2001):

(1) functional form; and

(2) variable selection.

The objective of the paper is to survey the functional forms (methods) used in real estate estimation. In this way, we can use the appropriate method according our criteria to estimate property value. There is continuing debate about the interpretation of value concepts by means of definitions of value and their implementation by means of a valuation methodology. As valuers move from operating in their home country to the demands of a European and international marketplace, these issues are likely to become more complex. Conversely, the cross fertilisation of ideas provides an opportunity for improved theory and practice.

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Price bubbles in housing markets

Concept, theory and indicators

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Abstract

Purpose – The purpose of this paper is to clarify the concept of bubble, what it means to explain a bubble and propose a list of bubble indicators.

Design/methodology/approach – The paper is based on a literature review and some philosophical ideas to derive conclusions for the problems studied.

Findings – A price bubble should be defined only in relation to the development of prices: a dramatic increase immediately followed by a dramatic fall. The traditional definition in terms of prices not determined by fundamentals is problematic primarily because the concept "fundamentals" is vague. A bubble can never be explained by a single factor, but is the result of the interaction of a number of factors. The explanatory factors proposed are used to derive a set of indicators working as warning signals whether a dramatic increase in prices will be followed by a dramatic fall. The list developed covers, for example, interest costs in relation to household incomes, the elasticity of supply, price expectations and credit conditions.

Research limitations/implications – Both the explanatory framework and the list of indicators should be seen as preliminary and the starting point for further development through empirical testing.

Practical implications – A developed list of bubble indicators could be useful for a number of actors, e.g. banks and authorities responsible for monitoring financial stability.

Originality/value – The contribution is a clearer and more useful concept of bubble, a clearer separation of the question whether bubbles exist and how they should be explained. The proposed list of indicators goes far beyond earlier indicators.

Keywords Pricing, Housing, Financial analysis

Paper type Research paper

1. Introduction

In the last five years there has been a discussion in many countries about whether there was a bubble on the housing market[1]. An interesting feature of this debate is the large disagreements between different participants, both among academic writers and in the more general debate. In the scientific debate, Case and Shiller (2003) and Shiller (2007a, b) argue that there were clear indicators of a bubble in the USA. This conclusion was questioned by e.g. Quigley (2003), Himmelberg *et al.* (2005) and Smith and Smith (2006). In the more popular debate *The Economist* in 2005 described the situation on the housing market as the largest bubble in history. But it is also easy to find popular articles arguing against this view, e.g. Krainer (2003).

Disagreements about price bubbles are not new. Garber (1990), e.g. argues that even in the classical bubbles – the Dutch tulipmania (1634-1637), the Mississippi Bubble (1719-1720), and the South Sea Bubble (1720) – there were perceived changes in fundamental factors that could explain the increase in asset prices.

The first thesis in this article, argued for in Section 2 below, is that these problems are related to an unsatisfactory definition of "bubble" mixing a descriptive component (price increases) with a (vague) explanatory component (not caused by "fundamentals"). The conclusion is that "bubble" should be defined only in terms of how prices behave.

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The second thesis argued for below is related to the debate about explanations of bubbles (focusing on why prices increase dramatically). One common argument is that the interesting type of dramatic price increase is one related to expectations about further price increases. In Section 3 below it is argued that explanations focusing on a single factor are unsatisfactory. Bubbles must be seen as the result of the interaction of a set of factors. A framework for such an explanation will be presented.

The third issue in focus here is the possibility to predict whether a dramatic price increase will be followed by a fall in prices. Much of the recent "bubble" debate was actually about whether the dramatic price increases would be followed by a serious fall in prices. In Section 4 this is discussed explicitly in terms of what a system of "bubble indicators" could look like. Given the conclusion that a complex of interacting factors causes bubbles, it is logical to try to develop a larger set of indicators, not just one or two as the price/income ratio or the price/rent ratio.

The focus in this article is on fluctuations in prices. Other issues in the area of "property cycles", e.g. cycles in construction activity, turnover and vacancies, will not be covered.

2. The definition of a price bubble: anti-Stiglitz'

2.1 Why we need the concept "bubble", but not Stiglitz' definition

When there is much controversy around a concept, and when there are several somewhat different interpretations, one possible solution is simply to discard the concept. An example is the concept of "the natural rate of unemployment" introduced in macroeconomics in the 1970s, only to be replaced in the 1980s with the clearer and less ideological term "non-accelerating rate of inflation unemployment".

However, a strong reason for keeping the term bubble is that asset prices develop very differently in different time periods. It is possible to observe periods with an extreme pattern of asset price behaviour – first a sudden dramatic increase in the asset price and then almost immediately a fall back to a level close to the original one. These periods are so dramatic that is seems rational to have a specific term referring to them, and such periods are also the historical origin of the term.

Most recent discussions about bubbles start from Stiglitz' definition reproduced below[2]:

> the basic intuition is straightforward: if the reason that the price is high today is *only* because investors believe that the selling price will be high tomorrow-when "fundamental" factors do not seem to justify such a price-then a bubble exists (Stiglitz' 1990, p. 13).

There are several problematic features of this definition. First, it does not refer to a bubble episode as a whole – both a price increase and a price decrease – but only discusses the increase in prices. From an historical perspective, the interesting thing to understand is complete episodes where prices first increase and then decrease.

The second problem with the definition is, as suggested above, that the definition includes reference to what can *explain* the price increase, and does this in two different but not identical ways. The first part defines bubbles in terms of prices being high today only because investors think it will be high tomorrow, while the second part focus on price increase not justified by fundamentals. The first part of the definition is however narrower than the second, as price increases not possible to explain by fundamentals, could be explained by other things than expectations of high prices tomorrow, e.g. unrealistic expectations about incomes or interest rates. The final problem is the vagueness of the central term "fundamentals". As will be discussed below, it is e.g. controversial whether real or nominal interest rates belong to the fundamental, and whether current and/or future expected rates should be included.

With hindsight it is clear that introducing several rather vague explanatory factors in the definition of a bubble was bound to lead to major disagreements about almost every episode in history.

The simplest solution seems to be define a bubble by focusing only on the specific development of prices and not on why the price has developed in this way. The general definition of a bubble would then simply be:

> There is a bubble if the (real) price of an asset first increases dramatically over a period of several months or years and then almost immediately falls dramatically.

2.2 Making the alternative definition more precise

As asset markets differ in their volatility and speed of adjustment it is necessary to give somewhat different interpretations of the general definition depending on the specific market analysed. The focus below will be on the housing market.

A first necessary feature of a bubble is then a "dramatic price increase". But what does "dramatic" mean here? In the most famous episodes called bubbles in the literature (see e.g. Garber, 1990), price increases of an asset have been more than ten-fold within a period of less than a year. The increase in the Nasdaq stock market in the late 1990s is another example of what must be classified as a very dramatic price increase. Looking at house prices, such large price increases have not occurred and are not very likely, and a dramatic price increase on the housing market could be defined as, for example:

- real prices have at least doubled during a five year period; and
- real prices have increased with at least 50 per cent during a three-year period.

The second and third necessary condition for a price bubble according to the definition above are prices falling back to something like the original level, shortly after the prices have peaked. This raises the questions; "How short must the time period be between the peak of the prices and when prices start to fall?" and "How quick and how much must prices fall?"

In the historical episodes described as bubbles there were no stable period with high prices after the dramatic price increase. The prices started to fall immediately after the peak. This might however be too restrictive, but it does not seem reasonable to see something as a bubble if house prices have stabilized on a high level, for example during a three-year period. Exactly where to draw the line is not important, but if we want to have a rather narrow concept of bubble maybe a one to two year period is the longest acceptable period between the time when the prices peaked and the time when they start to fall. Otherwise the price increase and the price decrease should be seen as two separate events.

Finally it is necessary to make a decision about how much prices have to fall. In many of the classical bubbles, prices fell back to (at least) the level before the price increase started. This might also be too restrictive. Suppose for example that house prices triple from 100 to 300, and then directly after fall with 50-150 per cent. Even if the price does not fall back to the initial level, it seems reasonable to see such a period as a bubble period as a 50 per cent fall must be seen as a dramatic fall in property prices.

There is no point in making a more exact general definition of a bubble. The numerical limits presented above must be adjusted to the historical patterns in the specific market and one also has to take into account the relation between the factors. An example is that the bigger the increase in prices, the larger deviation might be acceptable between the initial price and the price at the bottom after the downturn. The common focus is on periods that stand out from others in the sense that prices increase in an exceptional way and then falls back shortly after.

3. The explanation of a bubble – a general framework

3.1 What is an explanation?

In the philosophical literature a number of models of explanations can be found. The covering-law model is perhaps the most well known (see Hempel, 1965). A more complex model was formulated by Mackie (1974) in an attempt to explicate what is meant by a cause, and his model will be used here. Mackie summarizes the model by saying that for something to be a cause it has to fulfil a special condition, explained below, called an INUS-condition. The ideas behind these letters are the following.

First, an event occurs because there is a set of conditions that is Sufficient. This is the "S" at the end of INUS. For a fire to occur, the combination of a dropped burning match and a carpet that easily burns, might be such a set of sufficient conditions. A single factor is seldom sufficient to lead to a specific event. This means that if we want to understand an event like a bubble we should look for a combination of a number of factors in order to find sufficient conditions for the bubble.

This set of sufficient factors is not necessary. An event can usually occur because of somewhat different sets of sufficient factors. In the bubble context this means that one should not expect the complete set of factors sufficient for one bubble also to be found in other cases. The set of sufficient factors is Unnecessary (this is the U in the INUS-condition). There might be a large overlap between the sufficient factors for two bubble episodes, but there can also be expected to be some important unique events in each case.

When we talk about a cause of an event we usually pick one factor or a small number of factors as explanations, e.g. saying a bubble was caused by unrealistic expectations about future prices. The single factor focused on is an *Insufficient but Necessary part of the Unnecessary but Sufficient complex*.

From this perspective, explaining a bubble would be the same as to investigate the whole set of factors sufficient for the bubble to occur. In the next section an attempt will be made to create a structure for such an explanation, based on the factors often mentioned in the literature.

3.2 The explanatory framework

The hypothesis here is that by looking at the following dimensions it should be possible to present a set of sufficient conditions for a specific bubble episode.

3.2.1 The macroeconomic situation and macroeconomic policies. Bubbles typically start in a rather extreme boom period lasting for a comparative long period. It can also be hypothesized that it is a period where the macroeconomic policies have not been restrictive, as the boom then would not have been so strong.

3.2.2 Structural changes in the economy. A theme coming up in a number of studies of bubbles is that the period when the bubble starts is a period where it is more difficult than usual to evaluate what is "normal". The wave of deregulations in the 1980s has e.g. been mentioned as an example of such structural changes behind the real estate bubble in a number of countries around 1990. A parallel example is the discussion in White (1990) about the boom on the stock market in the late 1920s where he concludes:

"Fundamentals became difficult to judge because of major changes in industry". There is during the boom period at least some basis for the "New era theories" that Shiller (2000) criticizes.

3.2.3 The capital and credit market. When prices for assets increase dramatically, the actors must of course be able to pay these prices and then credit usually is necessary. Kindleberger (2005) underlines the role of the credit market for asset price bubbles:

> The thesis in this book is that the cycle of manias and panics results from the pro-cyclical changes in the supply of credit (p. 10)

The real estate bubble around 1990 in Sweden, one of the "Top 5 bubbles" in recent years according to Reinhart and Rogoff (2008), is in most analyses related to generous lending policies by the banks (see e.g. Lind, 1998).

3.2.4 The beliefs, expectations and plans of the actors. An important aspect of understanding the changes in the asset price is to know how the people who bought the asset at the high price argued and thought. It should be expected that people who buy an asset during a boom period have rather heterogeneous beliefs, expectations and plans, and the question is then the distribution between different groups in a specific period. Below is a number of interdependent aspects mentioned in various bubble debates:

Holding period: How many were buying but planning only to hold the asset for a short period of time? During a dramatic period with price increases, a larger share is expected to plan to sell shortly after they had bought the property.

Beliefs about the future development of the asset price: How many actors on the market think that prices will continue to increase, and for how long? This is the aspect focused on in the Stiglitz' definition, and it is also in focus in Case and Shiller (2003): People are paying a high price because they believe prices will be higher in the future. Waiting with entering the market will only make it more expensive.

A further example of the role of expectations is a hypothesis presented in Pastor and Veronesi (2006). They question whether there really was a bubble (in Stiglitz' sense) on Nasdaq around the year 2000. High uncertainty because of the new technology, meant that there was a (small) chance for at least some firms to be a new Microsoft. If the degree of risk-averseness is low, then it can be rational to pay very much for such a stock today even if current profits are low. It is like buying a lottery ticket.

The rationality of the actors: Do people have rational expectations about the future? The title of Shilles famous book – "Irrational exuberance" – points to the role of irrational expectations. The concept of rationality needs clarification and Nozick (1993) describes some important aspects:

> Two themes permeate the philosophical literature. First that rationality is a matter of reasons. A belief's rationality depends upon the reasons for holding that belief [. . .]. Second, that rationality is a matter of reliability. Does the process or procedure that produces (and maintains) the belief lead to a high percentage of true beliefs? (Nozick, 1993).

The hypothesis here is then that a larger share of actors, during the period with rising prices during a bubble, are not acting rationally in this sense. The behaviours of the banks in Sweden during the boom in the late 1980s are analysed from this perspective in Lind (1998).

3.2.5 The incentive of the individuals. A theme in a number of studies about bubble episodes is incentive system making it rational for individuals to make decisions that from outside looks irrational. Garber (2000), e.g. mentions that during the Tulipmania period many buyers "knew" they would not be forced to pay the price agreed in the contracts. Cole and Eisenbeis (1996) points to a number of principal-agent problems during the US savings- and loans scandal, and in the sub-prime crisis similar aspects can be found.

3.2.6 Summing up. Figure 1 gives an overview of the different dimensions to be analysed in order to find a sufficient condition for a specific bubble. In each dimensions there could be necessary conditions for the bubble, e.g. if there were no boom in the economy there would not have been any bubble, if incentives had been different then there might not have been a bubble, etc.

3.3 Bubbles: three ideal types

Explaining a bubble is, according to the arguments above, a type of historical explanation, focusing on the interaction of a number of factors and the interaction of individuals with different knowledge, different beliefs and plans – and with various incentives to take certain things into account. Even if each bubble episode has unique features it might be possible to construct a smaller number of "ideal types" of bubbles, where a specific mechanism dominates. Here are three such types.

3.3.1 Ideal type 1. A pure speculative bubble. In this case buyers believe the price of the asset today is too high and that the price eventually will fall, but believe in continuing price increases for some time, planning to sell with a profit before the price falls. Bubbles of this type have for example been observed in some laboratory experiments where the price of the asset at the end of the experiment is known (see Smith *et al.*, 1988). As the transaction cost is rather high on the housing market, it should not be expected that this kind of mechanism would dominate periods of rapidly rising prices on the housing market.

3.3.2 Ideal type 2. An irrational expectations bubble. In this case actors on the market become overoptimistic and think asset price will grow rapidly over a longer period of time. The growth is expected to be considerably higher than historical averages. Therefore it seems rational to pay a high price today. In this case the buyer plans to stay in the house or apartment for a longer period (keep the asset), but thinks it is reasonable to pay the high price because of a combination of assumptions not supported by historical patterns or other strong evidence, e.g. about high incomes and low interest rates.

3.3.3 Ideal type 3. The irrational institutions bubble. In this case the main mechanism behind the bubble is principal-agent problems, where actors have incentives to pay higher prices than what is supported by historical patterns or strong

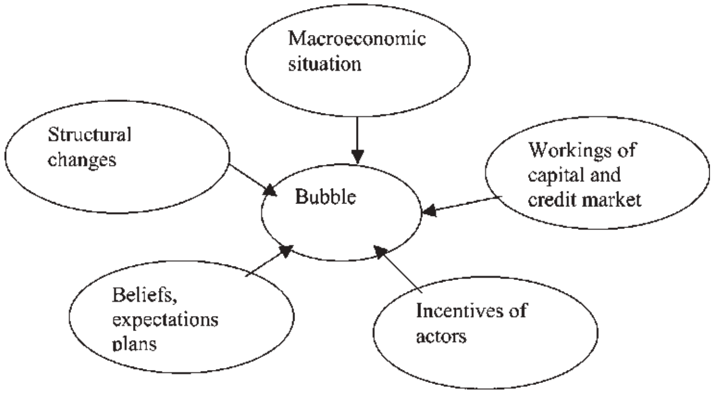

Figure 1.
Theoretical framework for explaining bubbles

evidence. There are several ways a principal-agent mechanism can push house prices above what is justified. The core of the mechanism is however, by definition that the buyer of the house/apartment does not expect to take the losses occuring when prices fall dramatically. The person who lends the money also expects to be able to shift the losses to someone else, maybe the government in the end. The sub-prime lending is the latest example of this (see Wheaton and Nechayev, 2008).

4. A system of bubble indicators

4.1 What is an indicator?

From a policy point of view the most important aspect of bubble theories is their predictive ability. Can they be used to indicate the probability that a period with a dramatic price increase quickly will be followed by a dramatic fall in prices? An indicator system would be a set of characteristics such that if they are at hand during a period of quickly rising prices, then it increases the probability for prices falling dramatically soon[3].

"Probability" can be given both more "objective" and more "subjective" interpretations. The objective interpretation would focus on characteristics observed in early phases of earlier bubbles, and draw the conclusion that if such characteristics are observed now then the likelihood of a downturn is higher. The more subjective, or theoretical interpretation, would go something like the following. In the long run, the market is determined by rational factors, by factors that a knowledgeable actor would take into account, and by the weight the knowledgeable actor would give them. If during a certain period with increasing prices it is observed that other factors are affecting the behaviour of the actors, then the probability for falling prices is higher. The "irrational" factors affecting the price would then be the bubble indicators[4].

Before presenting the list of indicators, it must be underlined that if the housing market is an efficient market where prices only are driven by new information, then there could not be any bubble indicators. In such a situation prices would be unpredictable and an increase would be as likely as a decrease. The development in behavioural finance (see e.g. Shiller, 2001, 2002) show, however, that market efficiency should not be taken for granted. In the end it is an empirical question whether it is possible to find any interesting empirical regularities on which indicators can be based, and if it is possible to predict whether the market is in a first stage of a bubble.

The only more systematic list of indicators found is one developed in a report from China Academy of Social Science (described in Xiaoling, 2007, p. 27). This is presented in Table I and it is based on price to income ratios, the price increase rate, rent to price ratios and investor psychology.

The indicators presented below are based on factors discussed in the literature. The list should be seen more as an hypothesis than as something rather final.

4.2 Prices and incomes

One common bubble indicator is the price/income ratio (see Table I above). One argument for using this indicator can be found in the empirical material presented in Case and Shiller (2003) where this relation is shown to be very stable over time in a number of regions (p. 308). It is also shown there that in a number of states where the relation increased, it later fell back towards an historical average (p. 311).

It should, however, be remembered that the purpose of the indicators is to identify cases where a strong increase in the price is (more) likely to be followed by a decrease. A strong increase in the price, e.g. 50 per cent in a three year period, will almost always lead to an increase in the price/income ratio, as incomes seldom increase so much. The indicator should therefore try to separate the cases where the increase in the price/income ration is likely to be followed by a large decline, from the cases where this is not likely. The simplest view, based on Case and Shiller (2003) is to say that a large increase in the price/income ratio, always will be followed by a fall, and then no special indicator would be needed. There are, however, several arguments against such a mechanistic use of the price/income ratio as bubble indicator (see e.g. McCarthy and Peach, 2004 and Himmelberg *et al.*, 2005). Households may care about the relation between housing expenditure and incomes, not the relation between price and income, and falling interest rates can the rationalize a higher price/income ratio.

The conclusion is that the price/income ratio is important to follow, and that the indicators should give us information about if a specific increase in the price/income ratio is likely to be followed by a fall. The price/income ratio as such is then not an indicator, but what the indicator should throw light on.

4.3 Housing expenditure

When constructing a bubble indicator related to housing expenditure it does not seem reasonable to focus on the standard user cost concept (as is done in e.g. Himmelberg *et al.*, 2005) as the user cost includes changes in the value of the property. During a period with rapidly increasing prices this user cost will seem to be rather low as there are dramatic increases in the wealth of the home owning households.

The direct expenditure should be in focus instead. Interest costs are a large part of the housing expenditure and a possible indicator is the relation between the nominal interest payments of the average buyer and their income. If this is significantly higher than in earlier periods, buyers might be acting in a non-sustainable way.

Several economists have argued for falling nominal interest rates as the fundamental explaining price increases from 1998 (see e.g. McCarthy and Peach, 2004), but there have been several criticisms of the use of nominal interest rates in this type of calculation (see e.g. *Economist*, 2005; Shiller, 2007a, b). The core of their argument is that if nominal interest rates fall because of lower inflation, then this would not motivate paying more for a house. Shiller (2007a) argues that the weight given to nominal interest rates should be seen as a change in "popular models" and reflects

Type	Specific index	Bubble reference standard Little bubble	Serious bubble	China current situation
Price index	Selling price	Housing price to income ratio <1.6	Housing price to income ratio >1.10	Almost 1:8
	Price increase race	Housing price increase rate/average income increase rate per capita >1	Housing price increase race >30%	Housing price increase rate/average income increase rate per capita >1
	Increase range	All kinds of property price increased nationally	All kinds of property price increased nationally	All kinds of property price increased nationally
	Rent level	Rent level index/CPI index <1	Rent level index <100	Rent level index/CPI index <1
	Investors' psychology	Quite optimistic	Very optimistic	Quite optimistic

Table I. An example of bubble indicators; housing price index money illusion[5]. This argument would then instead lead to a focus on the real (after tax) interest payments for buyers.

It is also necessary to clarify which nominal and real interest rate to use. The background to this question is the argument that homebuyers are thinking too much about the current interest rate and (irrationally?) think a current (low) nominal interest rate will last.

As both these issues are controversial, the proposal here is to include four different subindicators related to interest payments:

Indicatorgroup 1 – interest payments in relation to income for homebuyers

(1) Nominal interest payments in relation to income have been increasing.

(2) Nominal interest payment in relation to income would have been increasing if historical interest rate levels were applied.

(3) Real interest payments in relation to income have been increasing.

(4) Real interest payments in relation to income would have been increasing if historical interest rate levels were applied.

4.4 Housing supply

If, for example, falling interest rates were analysed from the perspective of a standard stock flow model, the argument would go like the following:

(1) Falling interest rates would lead to increasing demand for housing.

(2) In the short run with given supply, this leads to higher prices.

(3) The higher prices lead to increased profitability in housing construction and increased supply. This will continue as long as prices in the stock are higher than construction costs.

(4) The prices in the long run fall to a level determined by the level of construction costs (including land).

It is also possible to argue, using the so called Coase conjecture for durable goods, that there will be no dramatic increase in prices in step 2, as the buyers will realize that cheaper houses soon will come on the market. Explaining increased house prices with a falling interest rates would then presuppose myopic actors.

The supply side has been mentioned in the recent debates about bubbles, by e.g. Quigley (2003) and Goodman and Thibodeau (forthcoming). They argue that a price increase caused by, e.g. falling interest rates and increasing GDP is not a bubble, if it is very difficult to increase supply. The logic of this reasoning is clear from the stock-flow model, as the process then stops after step 2 above. A bubble sub-indicator should then focus on how difficult it is to increase supply in the areas where prices increase much:

Indicatorgroup 2 – housing supply

(1) The easier it is to increase supply, the more likely is the increased price a part of a bubble.

4.5 Buyer expectations about prices

One central idea in, e.g. Case and Shiller (2003) is that a sign of a bubble is people expecting increasing house prices even though prices already have increased a lot. This is related to the classical Stiglitz definition discussed above. Shiller (2007a, p. 8) says:

> I will argue that a significant factor in this boom was a widespread perception that houses are a great investment, and the boom psychology that helped spread such thinking.

Expectations about future prices can be formed in a number of ways. Beside the efficient market assumptions, people might build their expectations on longer or shorter historical trends, or on assumptions about mean reversion: that the probability of falling prices increases when prices have gone up a number of years. The hypothesis here is then that the typical situation during a bubble period is people having adaptive expectations based on a rather short period. Many actors on the market believe in prices continuing to increase as they did in recent years, and when prices has increased a lot people still do not believe in falling prices, but in prices stabilizing on what is a very high level from an historical perspective (see Wong and Hui (2006) for some evidence that support this). The households understimate the risk from housing investment. The indicators in this group are summarized below:

Indicatorgroup 3 – buyer expectations about prices

(1) Buyers expect prices to continue to rise or to stabilize on a level that is much higher than historical trends.

(2) Buyers believe that even in a median term perspective (three to five years) investing in housing is almost risk-free.

4.6 Buyer impatience and financial risk taking

The first idea here is that the probability of falling prices would be higher if, during a period with rising prices, households become more impatient: The cost of waiting is felt to be high, which might be related to herd behaviour, if many others have "realized their dreams" and, e.g. bought a house or apartment that is expensive in relation to their income.

The second aspect says that the risk for falling prices would be higher if households choose more risky financing alternatives. An extreme case is the kind of loan that led to the sub-prime crises in the USA, where interest payments and amortization where reduced the first years. A less extreme case is where a large part of the loans has interest rates that follow the current market rent and that these loans are taken during a period where the short run interest is low.

A third aspect of increased risk taking would be if the rate of amortization is low for home buyers compared to historical averages. As amortization is a way to build up reserves, a low rate of amortization means increased risk taking.

The indictors in this group are summarized below:

Indicatorgroup 4 – buyers risk-taking and impatience

(1) People are entering ownership at an earlier age or at a higher quality level.

(2) Buyers tend to choose riskier financing alternatives than earlier.

(3) Buyers are amortizing less than earlier.

4.7 The credit market

More risky financing choices by the households presuppose a supply of such lending. Kindleberger (2005) underlines that bubbles on the asset markets are "fuelled by" easy credit:

> The thesis in this book is that the cycle of manias and panics results from the pro-cyclical changes in the supply of credit (p. 10).

When the focus is on the housing market, easy lending should firstly be reflected in the loan-to-value ratios. From a mean-reversion perspective, loan to value rations should be reduced during an extreme boom, but if loan-to-value ratios even increase (everything else equal) then it would be an indicator of too easy lending. Another aspect is how the banks evaluate the borrowers' credit worthiness and whether there is a change in a more liberal direction.

Indicatorgroup 5 – bank behaviour

(1) Banks are increasing or at least not decreasing loan to value ratios for buyers on the housing market when prices increase.

(2) Banks become more liberal when judging the credit worthiness of households.

4.8 Speculative behaviour

The final bubble indicator concerns short run speculative behaviour. When housing prices are increasing rather quickly and if there are strong expectations of future price increases, then some people might see an opportunity for quick profits by buying an apartment or house and selling it again rather soon. This speculative behaviour might then further increase demand and prices. In many historical asset market bubbles this type of behaviour has been observed, even if it cannot be expected to be central on the housing market where transaction costs are high.

Indicatorgroup 6 – speculative behaviour

(1) A larger share of home-buyers than usual are planning to sell rather quickly again.

4.9 Final comments on indicators

The list of indicators presented above needs to be tested and developed in a number of ways. The first question is whether it is the right list. Besides leaving out the price/income ratio, the list also leaves out the relation between the rent level and the price level. Several authors have focused on this relation as a central bubble indicator (e.g. Taipalus, 2006), but it was not included above because many countries have rent regulations which make it difficult to interprete the rent/price ratio.

A second question is how the indicators can be made more operational. It is probably not possible to find a general scale for measuring the indicators as, e.g. financing structures differs between countries. The next step would however be to look at a number of countries and then try develop a measuring scale for each of the indicators.

5. Conclusions

Three main theses have been developed in this article.

5.1 The definition of bubble

Through history there have been periods where asset prices rose dramatically and then fell back to roughly the original level. These periods need a specific label that do not assume anything about why such a period occurs. The proposal here is to use the term bubble for these periods. The definition should then not include conditions like "price increases not determined by fundamentals".

5.2 The theory of bubbles

The framework proposed here is based on the idea that such dramatic developments of asset prices depend on the interaction between different factors. It is necessary to look at a whole complex of factors covering macroeconomic factors, structural changes, credit conditions, expectations among the actors in the market and principal-agent problems.

5.3 Bubble indicators

From a policy perspective the most important and most controversial thing is to to try to develop warning signals that function as indicators as to whether it is likely that a dramatic increase in house prices will be followed by a dramatic fall. If bubbles result from different sets of sufficient conditions, and the interaction of several factors, then the focus should be on a broad set of indicators. The list developed here covers, e.g. interest costs in relation to household incomes, the elasticity of supply, price expectations and credit conditions.

This way of structuring the problem of bubbles also points to a number of areas for future research, e.g. investigating a number of historical episodes with the theoretical framework described above. The list of indicators also need to be tested and made more operational.

Notes

1. In this article, "bubble" and "price bubble" or more specifically "asset price bubble" will be used as synonyms.
2. There are other definitions of bubbles, e.g. in Kindleberger (1978) where a "bubble" is defined as "a non-sustainable pattern of price changes or cash-flows" (p. 25) but these will not be discussed here as Stiglitz' definition is so dominating. Smith and Smith (2006) also present an alternative definition in terms of the relation between price and net present value of revenue from the asset.
3. There is an interesting parallel, not developed further here, to the much criticised German concept "Mortgage lending value". An attempt to defend this concept in terms of risk for falling prices can be found in Bienert and Brunauer (2007).
4. This idea might be behind Stiglitz' definition of bubble.
5. Égert and Mihaljek (2007), e.g. see the real interest rate as the fundamental.

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How small can a dwelling be? A revision of Portuguese building regulations

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Abstract

Purpose – The purpose of this paper is to study the minimum necessary net internal area of dwellings that should be established by Portuguese building regulations.

Design/methodology/approach – The following tasks are carried out: selecting the furniture and equipment necessary for each dwelling; determining the size of furniture and equipment and its typical arrangement; conceiving models of functional spaces; determining the net area of functional spaces and dwellings; comparing results with statistics on housing construction in Portugal and with mandatory area standards used in Portugal and ten other European countries.

Findings – The paper finds that the net internal area presently set by Portuguese building regulations should be increased by 5 to 15 percent. The net internal area figure obtained by the study is similar to mandatory regulations established by some other European countries.

Research limitations/implications – The study focuses on the net internal area of dwellings, although other space standards are also important to assuring the practicability of dwelling spaces; area standards were set on the basis of the current Portuguese situation and required adaptation when used in different social, cultural and economic contexts; area standards constitute a safety-net against unacceptable dwellings rather than good practice guidelines.

Practical implications – The results may be used to support a review of Portuguese building regulations and provide guidelines for the design of dwellings.

Originality/value – A methodology to determine area standards is presented and applied. Up-to-date information on furniture size and arrangements is collected. The comparison enables an understanding of how the results compare in a European context.

Keywords Standards, Housing, Buildings, Portugal

Paper type Research paper

1. Introduction

Residential space strongly influences the daily life of its users and is a determining factor for their quality of life and prospects for future personal development. In order to protect the comfort and well-being of future occupants, each dwelling should be adequate for the household which is likely to occupy it. The dwelling should therefore provide a safe, healthy, comfortable and functional environment, one that also provides aesthetic satisfaction.

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It is commonly understood that to ensure functionality, a dwelling should be big enough to meet the needs of its occupants for the activities of living, cooking, dining, sleeping, bathing and for the storage of household goods; it should also provide convenient access to adequate residential amenity space. Space standards establish the conditions to fulfil these objectives and usually regulate the overall area, size and dimensions of individual rooms, ceiling height and layout of dwellings.

The building regulations of several European countries include space standards for housing. In Portugal the space standards for new housing were established more than 30 years ago (Portugal Decree Law No. 38 382, 1951, ; Portugal Decree Law No. 650/75, 1975). No space standards apply to construction work in existing buildings.

The purpose of this article is to study the minimum net internal areas that should be established by Portuguese building regulations for existing and new dwellings. Four research questions are addressed:

RQ1. What is the minimum net area of dwellings adequate to current Portuguese living standards?

RQ2. How does the proposal for a minimum net area of dwellings compare to the requirements set by Portuguese building regulations?

RQ3. What would the impact be if the proposal was adopted as the minimum mandatory requirement?

RQ4. How does the proposal compare to the area requirements presently enforced in other European countries?

The methodology used to address these questions closely resembles studies carried out in other countries in the same field. The Portuguese experience will prove useful for other researchers.

The following section demonstrates the importance of space standards. Section 3 explains the research methodology and Section 4 addresses the results of the study on area standards. Section 5 presents the comparison of area requirements enforced in Portugal and other European countries. The results are discussed in Section 6.

2. The importance and definition of space standards

Space standards were introduced to set minimum habitability conditions, but have progressively lost their importance in the building regulations of several European countries. Space standards, for example, have been criticized as being an archaic relic of habitability standards and a symptom of over-regulation that restricts individual freedom. However, they have proved to be positive indicators of housing quality. They are simple to determine and verify and provide valuable information about dwelling space (Sheridan *et al.*, 2003).

Space standards are a measure of the acceptable intensity of dwelling occupation in the context of the prevailing cultural, social, climatic, economic and technological conditions in a particular society (Chowdhury, 1985). These conditions change with time, meaning that space standards should be updated regularly.

The study and establishment of space standards is important for several reasons (Sheridan *et al.*, 2003; HATC, 2006; Wren *et al.*, n.d.; English Partnerships, 2007):

- There is strong evidence that pressures arising from situations of overcrowding may lead to interpersonal aggression, withdrawal from the family, sexually deviant behaviour, psychological distress or physical illness. Furthermore, small homes which do not support the needs of occupants may lead to social cohesion issues (e.g. children who have no space at home to study or play hang around communal areas and housing estates), negative social behaviours (e.g. poor social control of children may give rise to violence and/or vandalism).
- Dwellings have a long lifetime, lasting for generations. It is not easy to anticipate the evolution of users' needs and their implications for space standards. A dwelling's flexibility enables its adaptation to the changing needs of users, but depends greatly on its initial spatial characteristics. Smaller dwellings have limited scope for flexibility and do not support the needs of growing families and a wider range of choices.
- The space characteristics of a dwelling, established during design and construction, are difficult to change during the rest of its lifetime. Spatial changes, when possible, usually require costly construction work.
- Dwellings with spaces adequate for potential users are likely to be viewed as more desirable by home buyers or tenants and therefore accrue a higher real estate or rental value. Dwelling area strongly influences construction costs.
- Social, economic and technological changes have accelerated in recent years. These changes have implications for the use of the home and consequently for space standards.

The space standards for social housing, in particular, deserve special attention for two reasons (Portugal Ministerial Order No. 580/83, 1983; Portugal Written Ministerial Statement No. 41/MES/85, 1985):

(1) One fundamental objective of social housing is to build quality dwellings at a reasonable cost. It is therefore important to optimize the cost/benefit relationship. The adequacy of the spatial characteristics of housing to the needs of occupants is a privileged way to optimize that relationship.

(2) While the state supports the construction of social housing, its acquisition or rental represents a significant financial obligation for the occupants. To make the best use of available resources and assure the affordability of social housing it is important to build dwellings that will satisfy occupants' needs over the foreseen lifetime of the building and are not bigger than necessary.

Housing standards are usually lower than the aspirations of the majority of occupants, who have the education and economic capability necessary to choose the dwelling that best fits their particular needs. Why then is it necessary to establish space standards? Couldn't the housing market just regulate itself? Unfortunately, if this was the case, the poorer sectors of the community might not be able to afford a decent house. If the market was not regulated, some families could be lodged in less-than admissible conditions (Davies, 1992). It is therefore the role of the state to ensure that:

- unfit dwellings are either demolished or made fit to live in; and
- new dwellings fulfil occupants' needs at a level that is equal to or above the minimum level admissible in current development standards.

Relevant studies to establish minimum space standards for housing have been developed in European countries for several decades (Klein, 1980; Griffini, 1948; Dreyfus and Tribel, 1961; Parker Morris Committee, 1961; Thiberg, 1970; Herbert *et al.*, 1978). The approach has become progressively more sophisticated over the years. Space standards have also been set in numerous design manuals (Neufert, 1970; Lamure, 1976; Tutt and Adler, 1979; Chiara *et al.*, 1992; Menghi, 1992). Later editions have updated some of these manuals. Recently, new studies were conducted to provide space standards which are up to date and adequate to the local context (Pedro, 1999; Boueri, 2005; HATC, 2006). These studies and design manuals were used as research literature for this study.

3. Research methodology

3.1 Parameters

The criteria used to establish occupants' needs were the number of people expected to occupy the dwelling, a classification of residential functions and two levels of quality (basic and minimum).

The needs of households with one to nine occupants were studied. Large households were studied because, although the average size of households in Portugal is 2.8 persons, 45 percent of the dwellings completed in 2007 were designed for six occupants and 17 percent for seven or more occupants (INE, Statistics Portugal, 2002, 2008). By using the number of occupants, it was possible to study a gradual increase in users' needs. Dwellings with different combinations of single, twin and double beds may be used to fulfil the needs of the same number of occupants.

The classification of functions enabled an analysis of the activities of occupants without setting a rigid use for each room. The description of dwellings' use with functions has been used in Portugal since the 1960s for studies of housing space standards (Portas, 1969) and occupants' behaviour (Pereira and Gago, 1974). The classification of functions was updated in later studies (Pedro, 1999). Table I presents the classification of functions used in this study.

The levels of quality reflect the degrees of fulfilment of occupants' needs and aspirations. As a fallback for unacceptable situations, two levels were set:

(1) The basic level ensures that occupants cannot suffer serious physical or mental injury. This level is usually used to evaluate whether an existing building is unfit for human habitation.

(2) The minimum level ensures that the common needs of users' daily life are fulfilled. This level is used to prevent the construction of new buildings detrimental to occupants or urban quality.

3.2 List of furniture and equipment

The furniture and equipment necessary for each number of occupants, function and quality level was selected. The selection criteria were the furniture and equipment indispensable to undertaking specific functions, usually put into place by the occupants, and indicated in other research literature. The furniture and equipment frequently used by occupants was identified from housing advertisements, post-occupancy evaluations (Figure 1) (Coelho, 1995, 2000) and surveys (Pereira and Gago, 1974).

Table I.
Use functions of the dwelling

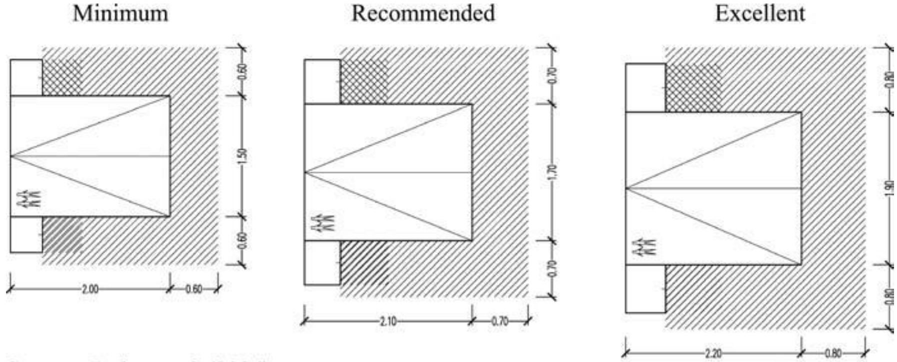
Function		Activities system
1. Sleeping	(a)	Double
	(b)	Twin
	(c)	Single
2. Cooking	(a)	Food storage
	(b)	Food preparation
3. Eating	(a)	Quick meals
	(b)	Dining
4. Living		
5. Play/study/work	(a)	Children play
	(b)	Adolescent play/study
	(c)	Adult play/work
6. Clothes care	(a)	Laundry
	(b)	Drying clothes
	(c)	Ironing clothes
	(d)	Sewing
7. Personal hygiene	(a)	Bath/shower
	(b)	Toilet
	(c)	Health care
8. Circulation	(a)	Entrance
	(b)	Communication/separation
9. Domestic management	(a)	Cleaning
	(b)	General storage
	(c)	Control of the environment
10. Being outside in private space		

Source: M. Menezes

Figure 1.
Photos of double-bed bedrooms in social housing in Portugal

3.3 Size of furniture and equipment

A market survey was carried out to determine the size of furniture and equipment. A sample of each item was built, using examples selected from furniture and equipment catalogues distributed in Portugal. Each sample item was organized by size, in increasing order. The sample was segmented in 50 percent, 75 percent and 87.5 percentiles, corresponding to the minimum, recommended and excellent levels of performance for each item of furniture and equipment (Figure 2). To correct possible deviations in the sample, these values were checked against the size of furniture and equipment described in the research literature. The size of access zones, the free space



Source: Pedro *et al.* (2006)

Figure 2.
Size of a double bed with bedsides and its access zones

necessary for the use of furniture and equipment (e.g. space in front of a chest of drawers to allow the drawers to open and close), were also set using the same research literature. These items of furniture and equipment and their access zones were drawn in parametric blocks in AutoCAD (Pedro *et al.*, 2006).

3.4 Typical arrangement of furniture and equipment

The furniture and equipment are usually arranged in certain configurations that result from certain factors: functional reasons (e.g. sequence of actions necessary to prepare, cook, and serve meals), rationality in the occupation of the space (e.g. kitchen with cabinets in an "L" leaving one corner for a table), and cultural values (e.g. Table in the centre of the room in line with the sideboard). The arrangements used most often were examined in the above-mentioned housing advertisements (Figure 3), post-occupancy evaluations of housing (Coelho, 1995, 2000) and surveys (Pereira and Gago, 1974).

3.5 Models of functional spaces

Models of functional spaces were drawn for each function. In the models, the furniture requirements set in 2.2 of Table I, with the size and access zones set in 2.3, were placed in the arrangements set in 2.4, allowing sufficient space for the occupants to be able to

Figure 3.
Layout of double-bed bedrooms taken from housing advertisements

move around within the rooms and to undertake normal activities. In some models the location of the door and window was considered (Figure 4). When several arrangements are possible the ones that require less surface area were chosen.

3.6 Functional space and dwelling areas

The analysis of the models enabled the area for each functional space to be determined. These values were checked with the research literature on the subject. The habitable area of the dwelling was obtained by adding up the area of all functions that are usually located in habitable rooms (living room, bedrooms and kitchen). The net internal area of a dwelling was obtained by adding up the areas of all its functional spaces.

3.7 Comparison of the results

The results were compared with the mandatory area requirements presently established in Portugal and in ten other European countries.

4. Minimum area standards

4.1 List of furniture and equipment

When determining the needs of furniture and equipment it was assumed that:

- A dwelling must enclose spaces to perform all the domestic functions, in order to allow autonomous use.
- A dwelling's spaces must have sizes and shapes that allow placement of the furniture and equipment necessary to satisfy the common daily needs of its occupants.
- Disabled persons must be able to access the dwelling. To assure this, at a minimum the entrance, living room, kitchen and a toilet must be accessible.

At the minimum level, furniture and equipment was attributed to all functions, with the following exceptions:

- children's play (5a), because it takes place during a short period in the family's life cycle. An alternative space for adolescent play/study was foreseen (5b);

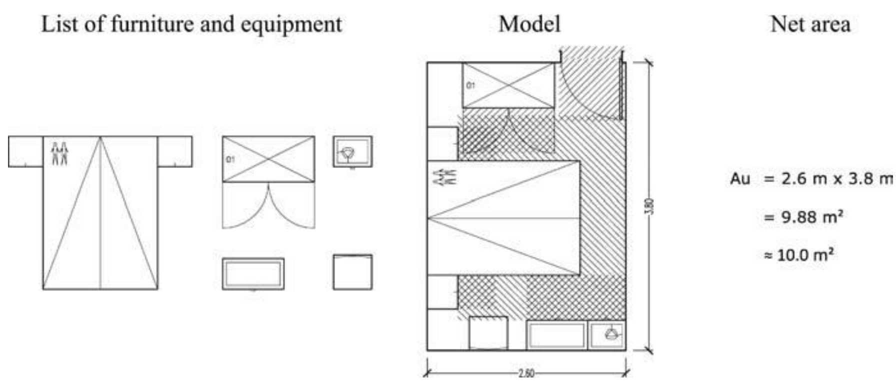


Figure 4.
Sleeping function (double bed)

- ironing (6c) and sewing (6d), because they can take place in a circulation zone or at a table;
- cleaning (9a) and control (9c), because no space is required; and
- being outside (10), because it can take place in common or public spaces.

Figures 5 and 6 present the furniture and equipment attributed to each function and number of occupants at the minimum level.

When determining the basic needs for furniture and equipment the programme adopted at the minimum level was used, except for the quick meals function (3a). For the remaining functions only the essential items of furniture and equipment were included. At this level, dwellings are not required to be accessible by disabled persons.

4.2 Areas by function

The area of each function (Tables II and III) varies gradually as the number of occupants involved in it increases. The only exception is the area for laundry (6a), which is constant, because the equipment planned is the same for all dwellings although the amount of clothing increases.

The area for circulation is 10 percent to 14 percent of the total area of the other spaces. These percentages were obtained by analysing the designs of seventy social housing units built in Portugal between 1990 and 1997. The increase in the circulation area is not entirely gradual, because of the need to balance additional spaces for personal hygiene in some typologies.

For the sleeping function three types of spaces were foreseen, with double, twin and single beds. In all dwellings with two or more occupants there is a double sleeping space. In dwellings with an odd number of occupants an additional single sleeping space is foreseen. The remaining sleeping spaces are twin. This distribution enables the possibility of dwellings being occupied by a couple and requires less area for the sleeping function. Different combinations can be created by dividing one twin bedroom into two single bedrooms.

Figure 7 presents each functional space, with its respective area, for the minimum level models.

4.3 Net internal dwelling area

The minimum areas of the dwelling for each number of occupants are presented in Tables IV and V. There is a gradual variation in the net internal area: at the basic level it increases 7.0 m^2 per occupant, and at the minimum level 9.0 m^2 per occupant. The index of net internal area per occupant is within the following limits (Figure 8):

- At the basic level, it is not less than 8.5 m^2 per occupant, considering the maximum number of occupants, and is 14 m^2 for the probable number of occupants, the limit below which the satisfaction of the inhabitants tends to be negative;
- At the minimum level, it is not less than 12 m^2 per occupant, considering the maximum number of occupants, and is nearly 20 m^2 for the probable number of occupants, the limit above which the satisfaction of the inhabitants tends to be positive.

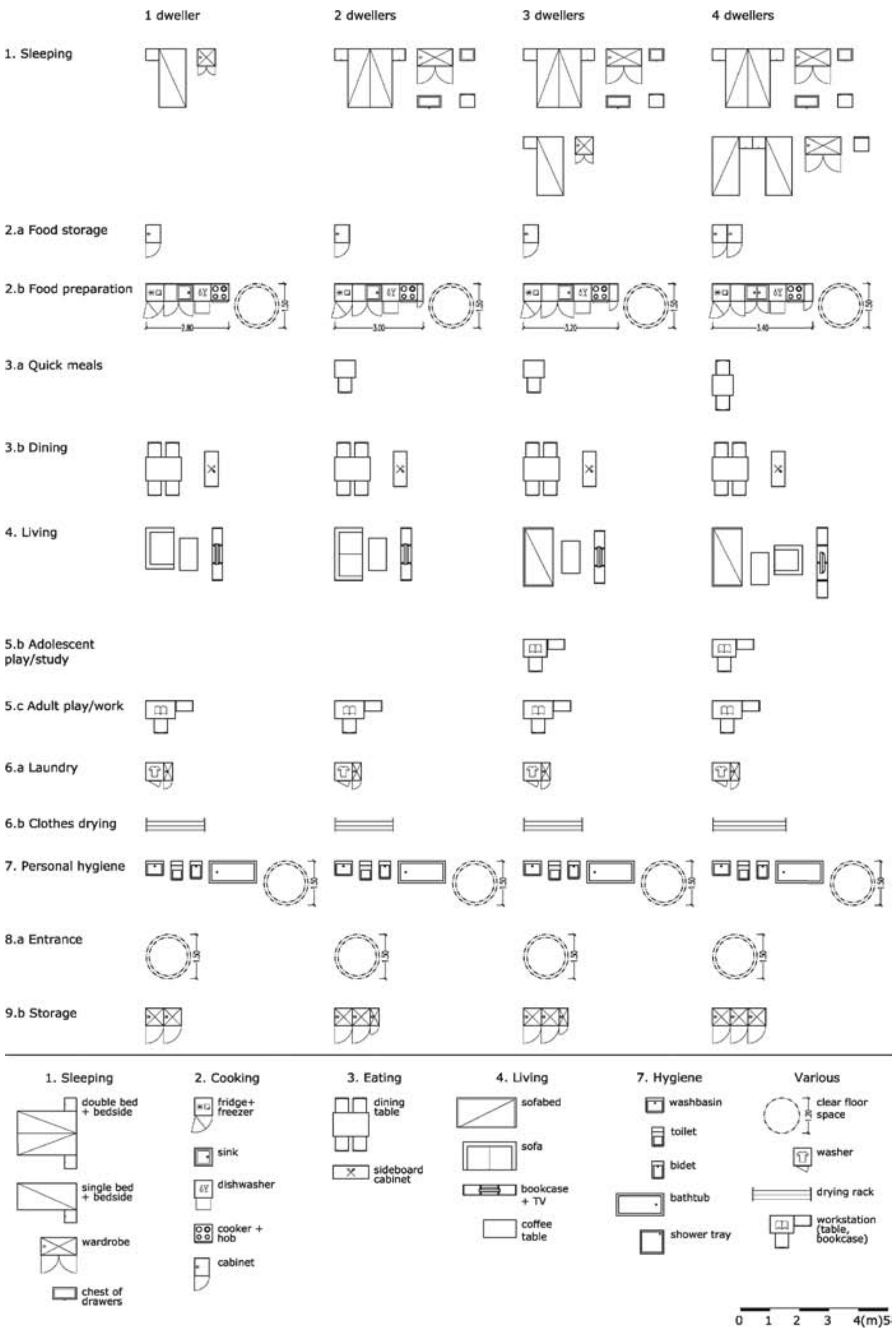


Figure 5.
Minimum level – list of furniture and equipment (part 1)

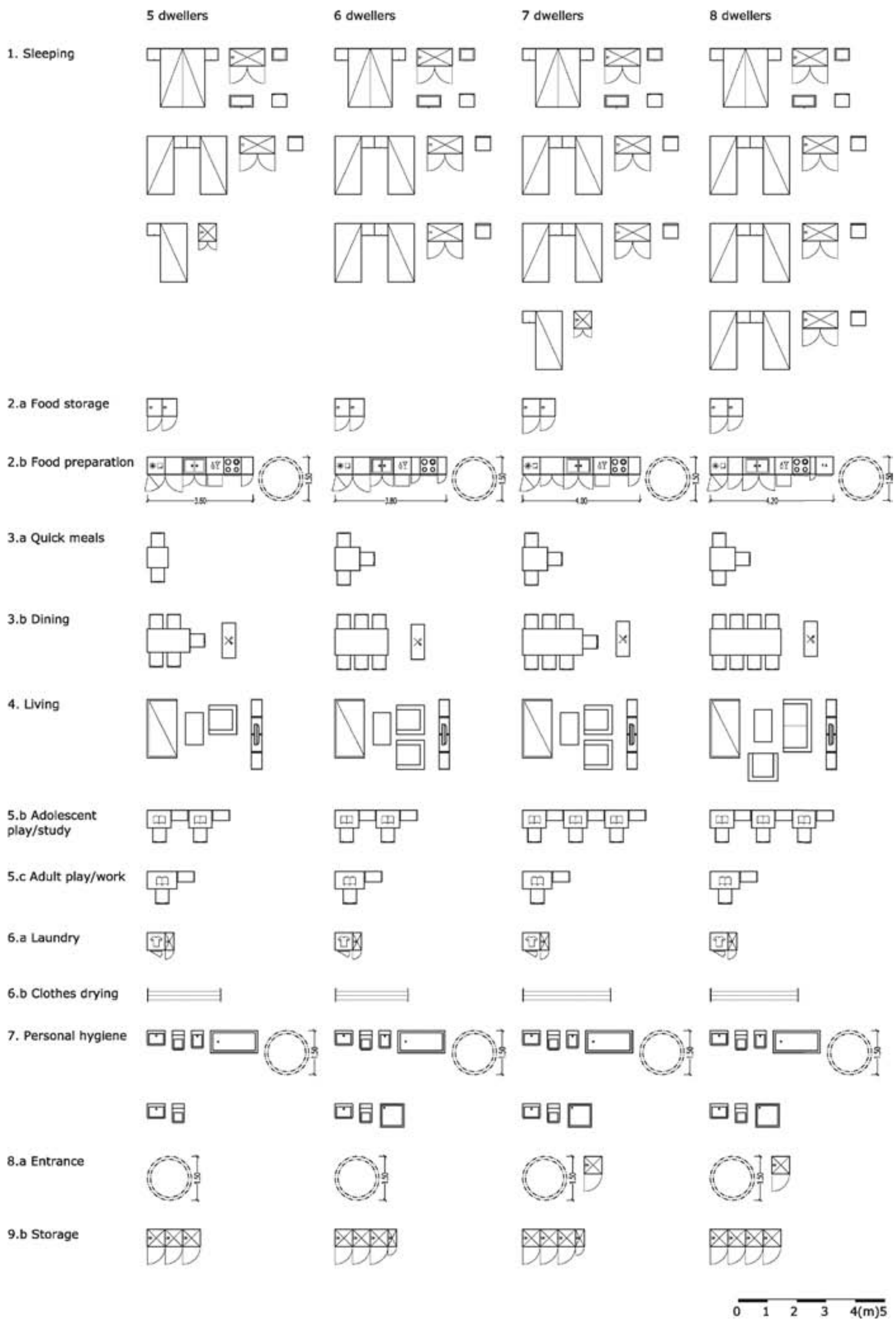


Figure 6.
Minimum level – list of furniture and equipment (part 2)

Function			Number of occupants 1	2	3	4	5	6	7	8	9
1	Sleeping	Double		8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
		Twin				7.0	7.0	7.0	7.0	7.0	7.0
		Twin						7.0	7.0	7.0	7.0
		Twin								7.0	7.0
		Single	4.0		4.0		4.0		4.0		4.0
2	Cooking	Food storage	0.5	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0
		Food preparation	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5
3	Eating	Dining	2.5	3.0	3.5	4.5	5.5	6.5	7.5	8.5	9.5
4	Living		4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0
5	Play/study/work	Adult play/work	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	Clothes care	Laundry	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		Drying clothes	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
7	Personal hygiene	Main	2.5	2.5	2.5	3.0	3.0	3.0	3.0	3.0	3.0
		Second						1.5	1.5	1.5	1.5
8	Circulation	Entrance	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0
		Communication	1.0	2.0	3.0	3.5	4.0	4.0	4.0	5.5	6.0
9	Domestic manag.	General storage	0.5	1.0	1.0	1.5	1.5	1.5	1.5	2.0	2.0

Note: Area for each function (m^2)

Table II.
Basic level

Function			Number of occupants 1	2	3	4	5	6	7	8	9
1	Sleeping	Double		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
		Twin				9.0	9.0	9.0	9.0	9.0	9.0
		Twin						9.0	9.0	9.0	9.0
		Twin								9.0	9.0
		Single	4.5		4.5		4.5		4.5		4.5
2	Cooking	Food storage	0.5	0.5	0.5	1.0	1.0	1.0	1.5	1.5	1.5
		Food preparation	3.5	3.5	4.0	4.0	4.5	4.5	5.0	5.0	5.5
3	Eating	Quick meals		1.5	2.0	2.5	2.5	3.0	3.0	3.5	3.5
		Dining	5.0	5.0	5.5	6.0	7.0	8.0	9.0	10.0	11.0
4	Living		6.5	6.5	7.0	8.0	9.0	10.0	11.0	12.0	13.0
5	Play/study/work	Adolescents			1.0	1.5	2.0	2.5	3.0	3.5	4.0
		Adults	1.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	Clothes care	Laundry	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		Drying clothes	0.5	0.5	0.5	1.0	1.0	1.0	1.5	1.5	1.5
7	Personal hygiene	Main	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
		Second					1.5	2.5	2.5	2.5	2.5
		Third									1.5
8	Circulation	Entrance	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	2.5
		Communication	1.5	3.0	4.5	5.0	5.0	5.5	5.5	6.5	6.5
9	Domestic manag.	General storage	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.5	2.5

Note: Area for each function (m^2)

Table III.
Minimum level

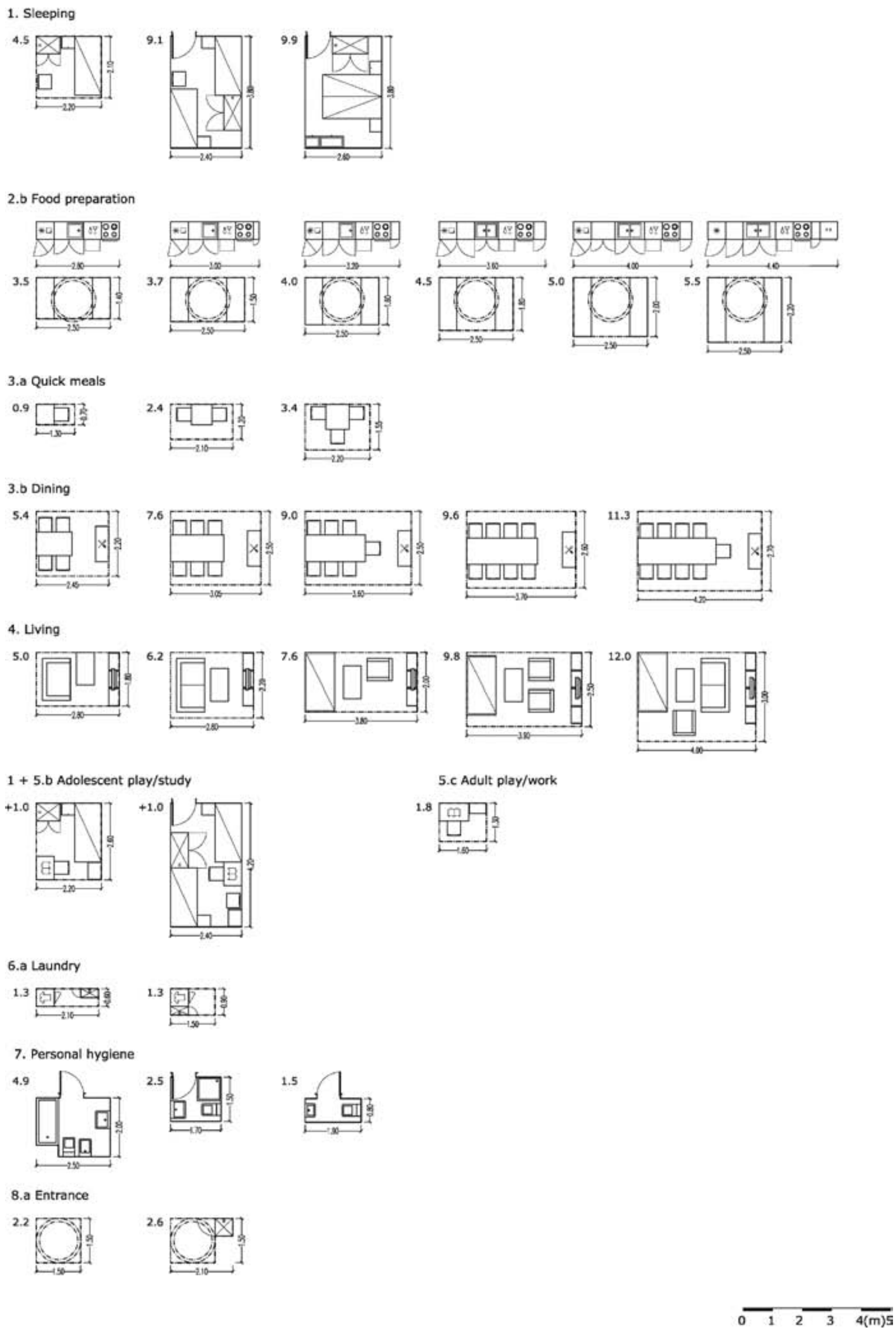


Figure 7.
Minimum level – models of functional spaces and their area (m^2)

Table IV.
Basic level

	Number of occupants								
Maximum	1	2	3	4	5	6	7	8	9
Probable	1	2	2/3	3	3/4	4	4/5	5	5/6
Habitable area	14.0	19.5	25.5	30.5	37.0	42.0	48.5	53.5	60.0
Net internal area	21	28	35	42	49	56	63	70	77
Net internal area per occupant (probable number of occupants)	21.0	14.0	11.7	10.5	9.8	9.3	9.0	8.8	8.6
Net internal area per occupant (maximum number of occupants)	21.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0

Notes: Area for each function (m^2)

Table V.
Minimum level

	Number of occupants								
Maximum	1	2	3	4	5	6	7	8	9
Probable	1	2	2/3	3	3/4	4	4/5	5	5/6
Habitable area	20.5	28.0	35.0	42.0	49.5	57.0	64.5	72.0	79.5
Net internal area	32	41	50	59	68	77	86	95	104
Net internal area per occupant (probable number of occupants)	32.0	20.5	16.7	14.8	13.6	12.8	12.3	11.9	11.6
Net internal area per occupant (maximum number of occupants)	32.0	20.5	20.0	19.7	19.4	19.3	19.1	19.0	18.9

Notes: Area for each function (m^2)

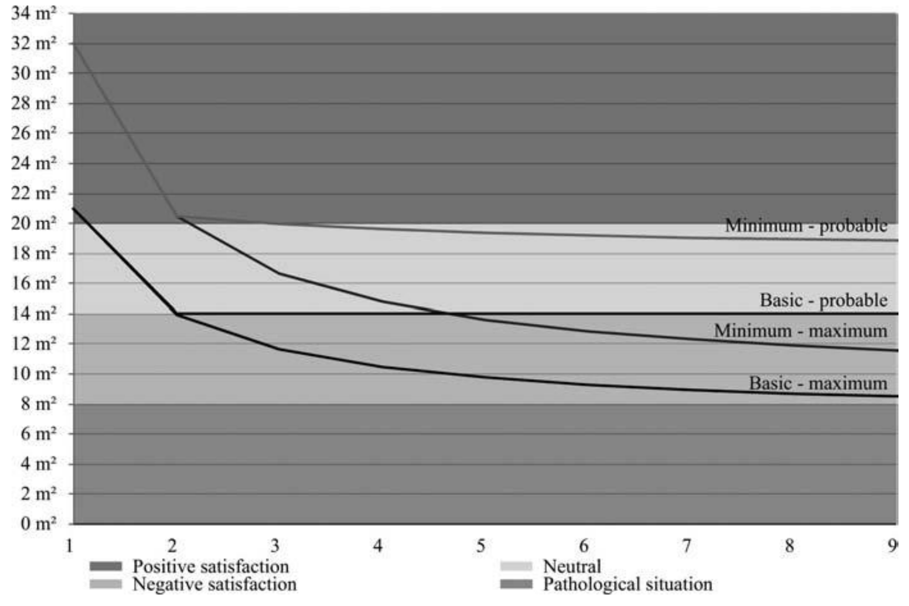


Figure 8.
Net internal area per occupant

5. Comparison

5.1 Comparison with area standards established in Portuguese building regulations

The *General Building Regulations* (Portugal, 1951, 1975) establish the minimum area for habitable rooms (bedrooms, living room and kitchen), toilets and bathrooms. Additional area must be added to the kitchen, the living room or to create a separate room for clothes care. These area standards are set by the number of rooms, and no standards are indicated for dwellings with three, five or eight occupants.

In order to enable the comparison the basic and minimum areas determined for each function (Tables II and III) were added to the sets of rooms where they usually take place. The living room, kitchen and supplemental area cover the cooking, eating, living and laundry functions. The bedrooms cover the sleeping and play/study/work functions. The toilet and bathroom cover the personal hygiene function.

Table VI presents the results. The conclusions are that:

- The area set for the basic level is 15 percent to 20 percent lower than the area established by the *General Building Regulations* for new dwellings. This decrease is understandable since the basic level is intended to verify whether existing dwellings, many of which were built before the current space standards came into force, meet minimum habitability conditions.
- The area set for the minimum level is 5 percent to 15 percent higher than the area established by the *General Building Regulations*. This increase is due to two main changes: the toilet and bathroom include clear space for a disabled person to move, and there is additional area for the play/study/work function, which increases the area of the bedrooms.

5.2 Comparison with Portuguese statistics on housing construction

The evolution of the area of new dwellings in Portugal from 1996 to 2007 was analyzed. There is statistical data available on building permits granted for dwellings, including the total number of dwellings by number of rooms and total habitable area. The

Number of occupants	1	2	3	4	5	6	7	8	9
Number of rooms	0	1		2		3	4		5
Living room, kitchen and supplemental area									
General building regulations	22.0	20.0	–	24.0	–	26.0	30.0	–	30.0
Proposal: basic level	15.5	12.0	14.0	16.0	18.5	21.0	23.5	25.5	28.0
Proposal: minimum level	22.0	18.0	20.0	22.5	25.0	27.5	30.5	33.0	35.5
Bedrooms									
General building regulations	–	10.5	–	19.5	–	28.5	35.0	–	44.0
Proposal: basic level	–	9.0	13.0	16.0	20.0	23.0	27.0	30.0	34.0
Proposal: minimum level	–	11.5	16.5	21.5	26.5	31.5	36.5	41.5	46.5
Toilet and bathroom									
General building regulations	3.5	3.5	–	3.5	–	5.0	5.0	–	6.0
Proposal: basic level	2.5	2.5	2.5	3.0	3.0	4.5	4.5	4.5	4.5
Proposal: minimum level	5.0	5.0	5.0	5.0	6.5	7.5	7.5	7.5	9.0
Total									
General building regulations	25.5	33	–	45.5	–	57	67	–	77
Proposal: basic level	18	23.5	20.5	35	42	48.5	54.5	60	66
Proposal: minimum level	27	34.5	41.5	49	58	66.5	74.5	82	91

Table VI. Area for sets of rooms (m^2)

habitable area in this case includes only the bedrooms, sitting rooms and living rooms. The kitchen is not included (INE, Statistics Portugal, 2008).

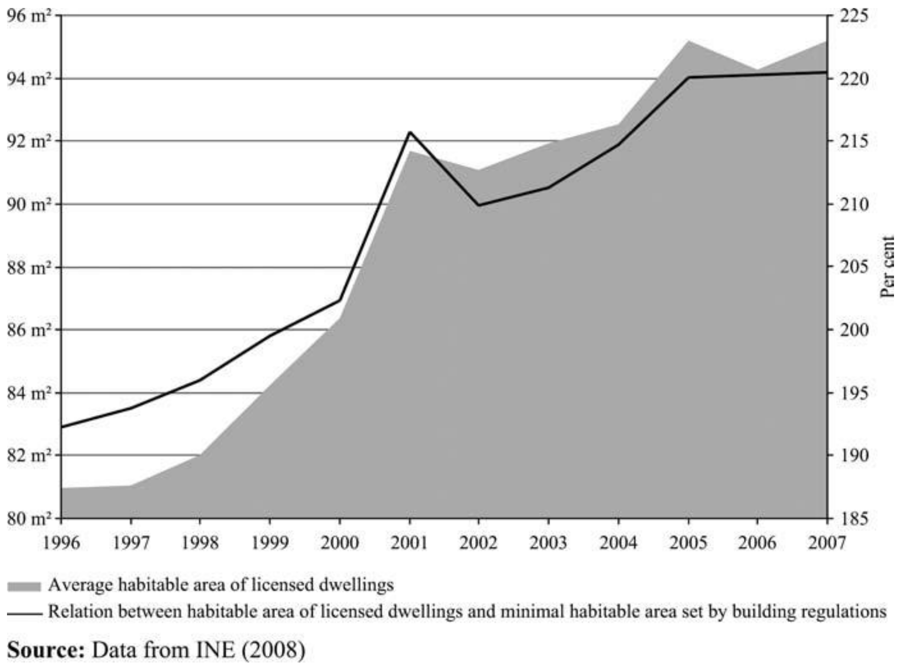
It was verified that the average habitable area increased gradually throughout the analyzed period, from 81.0 m^2 in 1996 to 95.2 m^2 in 2007. This difference constituted an increase of about 17 percent in 11 years. When comparing the total habitable area of the licensed dwellings with the total habitable area of the same dwellings according to the minimum values set by the building regulations, it was verified that in 1996 the first were on average 192 percent of the second, and that this percentage increased to 221 percent in 2007 (Figure 9). On average, dwellings are twice as big as the minimum standard (INE, Statistics Portugal, 2008).

The conclusion is that if the minimum level was adopted as a mandatory standard for the construction of new dwellings the impact would be small. The statistical data available do not enable us to determine how many dwellings granted a building permit would be below this standard.

5.3 Comparison with area standards in other European countries

An analysis of the space standards included in the mandatory technical regulations of several European countries shows that:

- In Belgium, using the Brussels Capital-Region as an example, the minimum areas for the habitable rooms in new housing are as follows: 20 m^2 for the living room, 8 m^2 for the kitchen, 14 m^2 for the first bedroom and 9 m^2 for the remaining bedrooms. The minimum habitable area of a dwelling with just one habitable room, including a living room and a kitchen, is 22 m^2 (Belgium Regional Building Regulations, 2006).



Source: Data from INE (2008)

Figure 9.
Comparing habitable areas of dwellings

- In Spain, using the Catalonia region as an example, the minimum net area of a dwelling, new or existing, must be 10 m^2 per occupant for the first four occupants and 8 m^2 for each additional occupant. The minimum net area for a new dwelling has been set at 30 m^2 and 20 m^2 for an existing dwelling (Spain, Catalonia Decree 259/203, 2003).
- In Finland the minimum net area for a new dwelling is 20 m^2 (Finland, Ministry of the Environment, 2004).
- In France, the minimum net area for a new dwelling is 14 m^2 per occupant for the first four occupants and 10 m^2 for each additional occupant (France Construction and Housing Code, 2008).
- In the Netherlands the minimum habitable area is 24 m^2 for new dwellings and 14 m^2 for existing dwellings. At least 55 percent of the net area of the dwelling must be habitable space. Therefore, the minimum net area of a new dwelling is 43.6 m^2 for new dwellings and 25.4 m^2 for existing dwellings. Part of the area can be in common habitable spaces (Netherlands, 2001).
- In Ireland, Building Regulations (1997), England and Wales, Building Regulations (2000), Norway, Technical Regulations under the Planning and Building Act, 1997 (2005), Sweden, Building Regulations (2002) and Denmark, Danish Building Regulations (2008) there are no quantitative area standards for dwellings in mandatory technical regulations.

In some countries, there are area standards that apply to only some types of development. For example, in England the English Partnerships' (2007) quality standards and in Ireland the Department of the Environment, Heritage and Local Government (2007) provide guidance on the minimum acceptable gross internal areas required in relation to occupancy and dwelling type. The guidelines from the English Partnerships are identical to the results of a study for the London Authority which also includes the minimum acceptable net internal area for 1 person and 7 persons (HATC, 2006). To be comparable with the net area, the internal gross floor area set for England and Ireland was divided by 1.15.

Table VII and Figure 10 present the internal net area of dwellings for several European countries.

Table VII. Net internal area set in several European countries (m^2)

Number of occupants	1	2	3	4	5	6	7	8	9
Number of bedrooms	0	1		2		3	4		5
Proposal: basic level (existing housing)	21	27	35	42	49	56	63	70	77
Proposal: minimum level (new housing)	32	41	50	59	68	77	86	95	104
Spain (new and existing housing)		20	30	40	48	56	64	72	80
Finland (new housing)	20								
France (new housing)	14	28	42	56	66	76	86	96	106
The Netherlands (existing housing)	24								
The Netherlands (new housing)	43.6								
England (new housing)[a]	37	44	57	67	81	92	105		
Ireland (new housing)[a]		39	54	63	74	81	91		

Note: [a] Adapted values

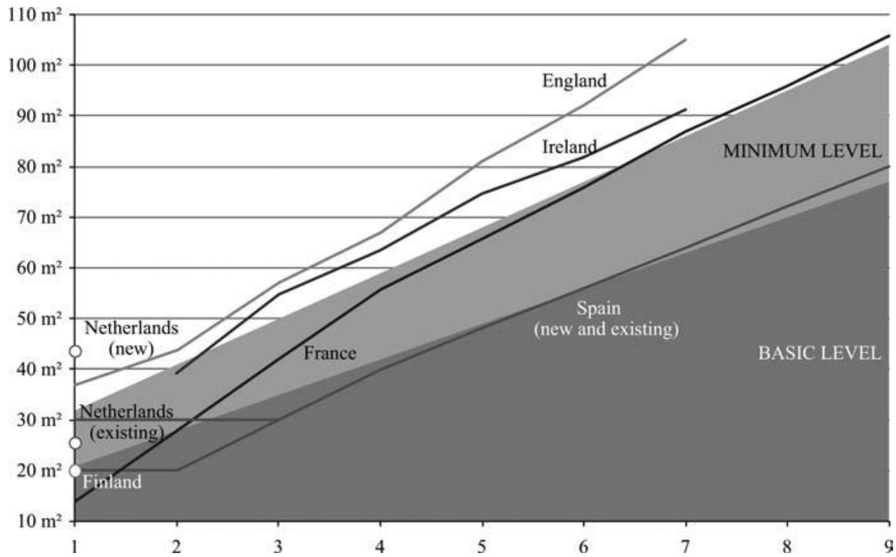


Figure 10.
Net internal area of dwellings by number of occupants

In most of the countries studied there are floor area standards for dwellings. These standards may be mandatory requirements, a condition for financial support or guidelines set by developers. Some countries have only a mandatory minimum size requirement for any dwelling, which ensures one person a dwelling of adequate size (e.g. The Netherlands and Finland). The justification is that space standards in dwellings designed for two or more people can be increased by under-occupancy (Wren, n.d.).

The conclusions are that there is a strong similarity of the basic level with the requirement in Spain, both applying to existing dwellings; in France similarity between the minimum level and the requirement is also strong, but only in dwellings for more than three occupants; the floor area guidelines in England and Ireland are greater than the requirements of other countries, which is reasonable since they are not mandatory for all developments.

6. Discussion and conclusion

6.1 Conclusions

The minimal net area for existing and new dwellings is presented in Tables IV and V. There should be an increase of 5 percent to 15 percent of the net internal area presently established in the Portuguese building regulations for new dwellings. The building regulations should also set a minimum net internal area for construction of existing dwellings, which can be 15 percent to 20 percent lower than what is presently established. If these proposals were adopted, the impact in the construction industry would be small. The proposals are similar to the mandatory net area requirements set in France and Spain.

The methodology adopted relates the needs of occupants with area requirements. Area requirements are not dependent on building types (flats, houses), tenures (owned, rented), locations (city, country), cost (affordable, cheap or expensive) or developers (social, private). The method for obtaining the net area of each function and dwelling is explained. If necessary, the list of furniture and equipment can be modified to determine different area requirements.

The functions used to describe occupants' use of the dwelling are not associated with rooms. The distribution of the functions and the associated areas is a design decision, which should aim to adjust each layout to the foreseen occupants. Conceiving rooms capable of accommodating different functions can be a design option. Usually, these flexible rooms require more floor area, yet they also enable the dwelling to be a platform that the inhabitants adjust to their way of life, instead of being conditioned by the characteristics of the spaces.

6.2 Limitations

This paper focuses on the overall internal floor space of the dwelling. This parameter enables us to study and compare the total size of a dwelling. However, other space standard parameters are also important to ensure a functional dwelling.

Area standards were established in order to meet the needs of occupants in contemporary Portugal. These needs are determined in part by social, cultural and economic factors. Therefore, the area standards should not be applied to different contexts without adaptation.

The area standards are a "safety net" intended to prevent the development of dwellings with inadequate space, which raise significant concerns about long-term sustainability and suitability for the designed level of occupancy. The area standards are not "good practice" guidelines.

The increasing amount of diversity in the composition of households and acceleration in the changing ways of life justify the need for dwelling flexibility. Flexibility discourages dwelling mobility and renovation work, and contributes to extending the useful life of buildings. Neither the change in needs of occupants nor an increase in area to allow greater flexibility was anticipated.

Area standards were set to enable adequate living conditions even in periods of maximum occupancy. However, this does not guarantee that during some periods the dwelling could be used by more persons than anticipated (overcrowding) and so does not permit adequate living conditions.

Space standards can be set by functional requirements (e.g. list of furniture and equipment to fit in a dwelling) rather than by minimum floor areas and dimensions. Functional requirements are a more effective and flexible way to ensure that sufficient space is provided, since they reflect issues such as room shape and the position of windows and doors. However, functional requirements have the disadvantage of being more complex to use and verify.

The life of the occupants takes place in a continuous space, which includes dwellings, a building's common spaces, a neighbourhood's public spaces, nearby collective equipment, etc. There can be some compensations of area between the dwellings and its environment (e.g. a dwelling with no area for children to play can be compensated for by a generous common garden).

All the necessary spaces for the autonomous use of each dwelling were foreseen. Some functions or activities can be relocated to common spaces (e.g. clothing care can take place in common laundry facilities). These changes should only be made with the agreement of the future occupants.

The area standards drew upon a function-based and user-oriented approach. User satisfaction with existing dwellings and stakeholder views were not investigated. Should the proposed standards be used to replace the mandatory *General Building Regulations* requirements, they should be critically assessed in terms of these two sources of information.

6.3 Future developments

The study focuses on the net internal area of dwellings. Its continuation will enable a review of the remaining space standards for dwellings.

The net internal area was determined on the basis of existing knowledge on dwelling use. No empirical studies were carried out to update this knowledge. It is necessary to study how dwellings are presently being used in Portugal and foresee the future evolution of their use. This will enable a review of the area requirements for each function and of the dwelling.

Area requirements were determined for occupants without special needs. The study of area requirements for dwellings used mainly by old persons or by disabled persons will support planning special dwellings (e.g. with accessible, adaptable, or universal design features).

Area requirements are defined in legal documents in the majority of European countries, to assure adequate conditions for use. Different parameters are used to set these requirements. The comparison of legal documents from different countries would enable an analysis of which parameters permit the designer as much freedom as possible in how area is distributed among different rooms, and are easy to verify with the building authorities.

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The value of a floor: valuing floor level in high-rise condominiums in San Diego

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Abstract

Purpose – This paper aims to analyze the effect of floor level on condominium prices in San Diego, California. The authors determine whether "higher-floor premiums" exist in the condominium market for a large California city. Further, they investigate how the floor premium varies throughout a building, particularly whether it is quadratic and whether there is a "penthouse premium" for top-floor units.

Design/methodology/approach – The paper utilizes a data set of 2,395 condominium sales occurring in San Diego between 2006 and the second quarter of 2011. Using hedonic pricing analysis, the authors model the housing price as a function of condominium, building and neighborhood characteristics.

Findings – The results suggest that there is a higher-floor premium for condominiums in San Diego. Specifically, an increase in the floor level is associated with about a 2.2 percent increase in sale price. The higher-floor premium appears to be quadratic in price, suggesting that price increases at a decreasing rate above the mean floor level. The authors also find evidence for a penthouse premium, though this effect disappears once "floor" is controlled for in the model.

Originality/value – There has been little direct research on the floor effect in condominium prices. The studies that have used floor level as an explanatory variable have been predominately in Southeast Asia. The results suggest that the floor effect is more complex than previously modeled.

Keywords Hedonic pricing, Penthouse, Higher-floor premium, Value of floor, Condominium, San Diego, United States of America, Housing, Prices

Paper type Research paper

Introduction

There is a growing body of research that suggests that higher condominium floors confer higher sale prices, controlling for square footage and other relevant attributes. Evidence for this "higher-floor premium," however, has been somewhat narrowly presented in two regards. First, reporting of a higher-floor premium has been largely incidental, as "floor," "level" or "story" are included merely as control variables for investigations of other matters. As such, there is a dearth of analysis of this particular finding, i.e. whether it is linear, nonlinear, monotonically increasing by floor, etc. Second, the investigations have occurred primarily in Southeast Asia, Hong Kong in particular.

Background

Mok *et al.* (1995), estimate a hedonic pricing model for 1,027 condominiums sold in Hong Kong in August 1990. While they seem to have little information on the structural characteristics of the condominium (other than gross floor area and the age of the building), they do include the floor level of condominium within the building and

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whether there is a sea view. Using sales price as the dependent variable, the authors estimate four different specifications and find floor level to have a positive and significant impact on price in all four specifications. Other studies of Hong Kong offering similar conclusions include So *et al.* (1997), Chau and Ng (1998), Chau *et al.* (2001), Tse (2002) and Chau *et al.* (2003).

Two other studies find similar results for Singapore. Ong (2000) investigates 15 large (over 200 units) residential condominium developments in Singapore from 1988 to 1998 and finds that the higher the floor of the unit, the higher the probability of observing a subsequent sale within the time frame studied (i.e. higher turnover rate) and the higher the (mortgage) prepayment rate. Ong (p. 595) comments that the finding of a higher probability of a subsequent sale is "consistent with the commonly held perception that units on higher floors are more desirable." Similarly, Sun *et al.* (2005) analyze condominium sales data for Singapore from 1990 to 1999 using several models that control for spatial autocorrelation and find a consistent, positive relationship between floor level and sales price. Chin *et al.* (2004) examine 442 condominium sales in Malaysia for the years 1996 and 1998. Through several different specifications, the coefficient on floor level remains positive and statistically significant.

While there appears to be empirical evidence for a higher-floor effect, why might this be the case? We posit two potentially competing theories that could affect higher-floor prices. On one hand, higher floors take longer to reach from the ground floor thus increasing travel times. Ceteris paribus, this would likely exert a negative influence on price as higher travel times increase travel costs. The implicit value of time is at the core of economic theory. Research conducted in a myriad of situations has confirmed that individuals place a value on their time and that this can vary based on a variety of factors, including income (i.e. opportunity cost) and impatience. Thus, it should be no surprise to learn that hedonic pricing models for residential housing often find that, controlling for square footage, distance from the central business district (CBD) is negatively related to housing prices – driven by the well-known, "negative rent gradient" (Muth, 1969; Mills, 1972; Colwell and Sirmans, 1978; Kau and Sirmans, 1979; Ohkawara, 1985; Coulson and Engle, 1987; So *et al.*, 1997; Chau and Ng, 1998). In short, ceteris paribus, workers prefer to live closer to work in order to reduce travel times. Thus, to the extent that living on higher-floored units in a multi-floored condominium increases travel times for residents we might expect the price of condominium units (controlling for other factors) to decline with floor level. At a minimum, this effect – call it the "negative travel effect" – would put negative pressure on prices of higher-floored condominium units. This effect is unlikely to occur in the San Diego condominium market, which is characterized by fairly new buildings of moderate height.

At the same time, there is considerable evidence that buyers prefer housing that is located away from traffic or road noise. Brandt and Maennig (2011), for example, find that doubling road noise in Hamburg, Germany would reduce condominium prices by 2.3 percent. Buyers have also been found to value locations and near amenities such as forests (Tyravinen and Miettinen, 2000), lakes (Kilpatrick *et al.*, 2007), trails and greenbelts (Asabere and Huffman, 2009), ponds (Plattner and Campbell, 1978), green spaces (Conway *et al.*, 2010), historically significant buildings (Narwold *et al.*, 2008) and open spaces (Irwin, 2002). For cities located near the ocean, such as San Diego, this could manifest itself as a desire to locate near the coast (Conroy and Milosch, 2011; Rinehart and Pompe, 1994; Major and Lusht, 2004). Similarly, research has found positive view effects from locating near a large body of water. A recent investigation in Europe by Baranzini and Schaerer (2011), for example, found that rent premiums for housing located near "an extended surface of water" were as high as 3 percent and housing with a view of "water-covered area" could be as high as 57 percent. Previous investigations by Rodriguez and Sirmans (1994) and Benson *et al.* (1998) found similar results in the US. Together, these findings suggest that condominium units located on higher floors – those that get above the traffic noise and may include a view – may be valued higher than their lower-floored counterparts. In short, this "positive ambience effect" would drive up prices of higher-floored condominium units. Given these two competing forces on residential unit prices of multi-floored condominiums, it is unclear ex ante whether higher-floored condominium units would sell at higher prices or lower. In this current endeavor, we investigate this issue to determine which effect dominates, i.e. what is the net effect on prices, while controlling for other relevant price determinants or amenities. Put differently, is there a "higher-floor premium" for residential units in San Diego, California?

Further, if higher floors are associated with higher rents, then perhaps units on the top floor – the penthouse units, as they are often called – offer an additional premium? While this seems to be true anecdotally ("penthouse" is often listed as an amenity in rental or real estate sales advertisements), surprisingly, we are not aware of any other studies that have investigated whether penthouse condominium units confer higher value, controlling for square footage and other important amenities. Since this is a natural extension of our "floor" analysis, wish to investigate this here.

Data

The data for this study come from the sale of 2,395 condominium units in the downtown San Diego market over the five-year period of July 1, 2006 through June 30, 2011[1]. Real estate professionals involved in residential real estate in downtown San Diego generally classify five distinct sub-markets or "neighborhood" in the area. These markets are indentified as the Marina District, East Village, Cortez Hill, the Core, and the Columbia area. These, as well as other major landmarks such as Coronado Island, and San Diego Bay are shown in Figure 1. The Marina District has both close proximity to San Diego Bay, the San Diego Convention Center and the Gaslamp entertainment area, a gentrified area of the city that has become a hot spot for restaurants, bars and entertainment. The dominant feature in the East Village is Petco Park, home of San Diego's professional baseball team, the Padres. Cortez Hill, as its name implies, is an elevated portion of downtown populated with older buildings. The Core is the traditional CBD for San Diego and contains mostly commercial high-rises. Development in the Columbia area is centered around the historic Santa Fe Railroad Depot and, along with the Marina and East Village includes water front.

Methodology

Following seminal work in the area of hedonic pricing by Ridker (1967), Ridker and Henning (1967) and Rosen (1974), there are four common methods for estimating condominium sales price variations: standard OLS hedonic price function, log-log, semi-log and Box-Cox transformations. While there is no theoretical motivation for any particular functional form, the two most common forms estimated are the semi-log and Box-Cox transformations. Box-Cox transformations have been shown to reduce coefficient bias (Blackley *et al.*, 1984; Cropper *et al.*, 1988) and semi-log transformations are also appropriate in cases such as these where there are long right-hand side tales

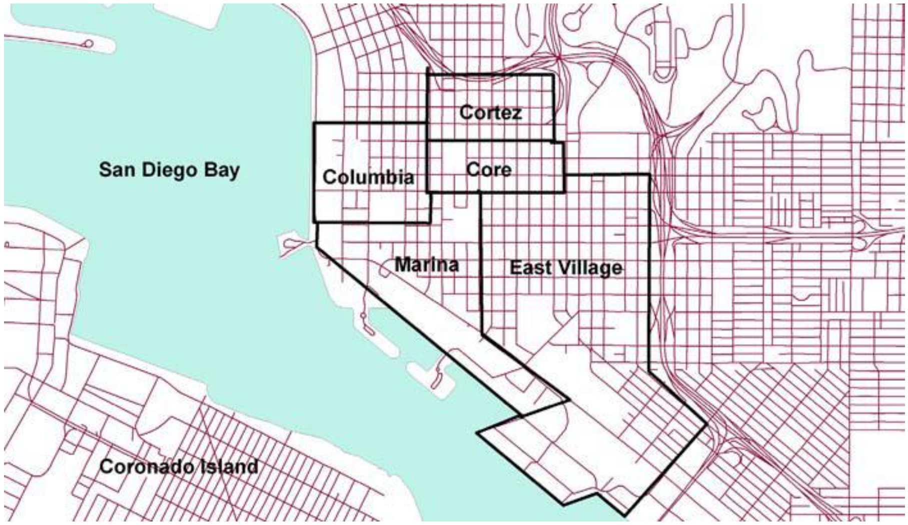

Figure 1.
Map of downtown San Diego and neighborhoods

on the dependent variable. Following Brandt and Maennig (2011), Conroy and Milosch (2011), Mahan *et al.* (2000) and Irwin (2002) and many others, we use the semi-log transformation here. The semi-log transformation has the added advantage of ease of interpretation of the coefficients (see below).

In hedonic pricing studies, the value of the house (or condominium unit) is considered to be a summation of the value of the characteristics of that house. The characteristics may be categorized in terms of location, market conditions, or attributes of the structure itself. Differences in the quantity and quality of these attributes then drive the differences in the market value of housing, which is assumed to be in equilibrium. Since there is no market for the attributes that comprise a house, the prices of the attributes are not directly observable. Rather regression analysis is employed to place a value on the attributes. More formally, let there be i site and structural attributes, j location characteristics and k market factors. The semi-log regression equation can be written as:

$$\ln(P) = \alpha + \beta_1 S_1 + \cdots + \beta_i S_i + \lambda_1 L_1 + \cdots + \lambda_j L_j + \mu_1 M_1 + \cdots + \mu_k M_k + \varepsilon, \quad (1)$$

where P is the sales price of a house, β, λ and μ are coefficients, and ε is an error term. Site and structural characteristic variables include age, number of bathrooms, bedrooms, and square footage of the unit, which have been found to be important predictors of housing prices (Sirmans *et al.*, 2006). Location characteristics include dummies for each of the neighborhoods, Columbia, Core, Cortez, East Village and Marina as well as our variable of interest, "floor," and related variables such as floor-squared, total number of floors in the condominium, and a top-floor, "penthouse" indicator. We control for market factors by including year indicator variables which should capture any year-specific market effects. Given the changes that were taking place in local housing markets (and, indeed, nationwide) during the survey time (2006-2011), we expect this to be an important control.

In Table I, we present the descriptive statistics of the data set for the condominium buildings within the five geographic areas (or "neighborhoods"). Condominium sales occurred in buildings ranging in age from one to 82 years old. The vast majority have been built in the past ten years. Likewise, there is a large variation in the size of the buildings, with several at four floors (our minimum cutoff for this investigation), and the highest with 43 floors. Comparing this sample to other locations such as Hong Kong, or even New York, Chicago or San Francisco, the average high-rise condominium in San Diego is relatively low[2].

Similar variation exists in the characteristics of the individual condominiums (Table II). Condominium sales prices range from slightly more than $100,000 to over $4 million. The average condominium has a floor area of around 1,100 square feet, but there are units with as few as 296 square feet to as many as 4,528 square feet. Not surprisingly, condominium prices in the San Diego market fell throughout the five-year period included in the data set. We include a series of six “year” dummy variables to capture any changes in market prices over this time that could have been associated with the general real estate market decline. The average floor level on which a unit sold is 8.79, or nearly the ninth floor. The average total number of floors in a condominium for those units who sold is 18.15. The highest volume of sales occurred in the East Village (28.22 percent), with the Core having the fewest (6.40 percent). The five-year data collection period went from the third quarter 2006 through the second quarter 2011. However, the smallest number of sales occurred in 2009 (7.9 percent) due to data collection limitations (see footnote above).

Results

We estimate three basic models and present them in Table III. In the first estimation, Model 1, we include a “penthouse” indicator variable for units located on the top floor of a condominium building. We do not include a “floor” variable in this model. The results from Model 1 support a positive “penthouse effect,” with a coefficient of 0.0452, suggesting that the penthouse is associated with a 4.35 percent higher price, even when controlling for the other factors[3]. Thus, our anecdotal prior belief about the positive value of a top-floor unit is supported by these results. In Model 2, we include our variable of interest, “floor” and note that the coefficient for “penthouse” is no longer significant. The positive penthouse effect seems to disappear once floor level is controlled for.

Results presented in Model 2 are quite similar to those for previously-published papers. The coefficient for “floor,” is positive and very significant. In fact, increasing the “floor” by one level is associated with a 2.2 percent increase in sales price. The coefficient for “age” is negative and indicates that each year is associated with about a 0.57 percent decrease in sales price. This may be due to the fact that older housing stock may require more repairs and upgrades due to a depreciating capital stock. As expected, the coefficients for “baths,” “bedrooms,” and “square footage” are positive

Sub-market	Units sold	Average total floors	Minimum total floors	Maximum total floors	Average age of buildings	Average sales price ($)
Columbia	695	28.7	4	43	6.3	617,904
Core	165	11.5	4	19	7.6	339,261
Cortez	468	13.2	5	40	9.8	389,009
East Village	728	13.8	6	33	4.7	427,916
Marina	524	16.7	4	41	10.3	649,478
Total	2,580	18.1	4	43	7.4	511,367

Table I. Descriptive statistics of buildings by geographic region

Variable	Mean	SD	Minimum	Maximum
Sales price	$511,367	$338,431	$120,500	$4,250,000
Ln sales price	12.99	0.523	11.70	15.26
Age	7.36	9.54	1	82
Baths	1.64	0.559	1	4
Bedrooms	1.53	0.631	0	4
Square footage	1,093.8	408.05	296	4,528
Penthouse	0.088	0.283	0	1
Floor	8.7	7.8	1	43
Floor squared	139.5	254.1	1	1,849
Relative floor	0.52	0.28	0.02326	1
Total no. floors	18.14	11.99	4	43
Columbia	0.26	0.44	0	1
Core	0.06	0.24	0	1
Cortez	0.18	0.38	0	1
East village	0.28	0.45	0	1
Marina	0.20	0.40	0	1
Sale in Q2-2006	0.05	0.21	0	1
Sale in Q3-2006	0.03	0.18	0	1
Sale in Q4-2006	0.05	0.23	0	1
Sale in Q1-2007	0.07	0.25	0	1
Sale in Q2-2007	0.04	0.20	0	1
Sale in Q3-2007	0.03	0.18	0	1
Sale in Q4-2007	0.04	0.19	0	1
Sale in Q1-2008	0.05	0.22	0	1
Sale in Q2-2008	0.03	0.19	0	1
Sale in Q3-2008	0.03	0.18	0	1
Sale in Q4-2008	0.03	0.19	0	1
Sale in Q1-2009	0.03	0.18	0	1
Sale in Q4-2009[a]	0.04	0.20	0	1
Sale in Q1-2010	0.05	0.21	0	1
Sale in Q2-2010	0.06	0.25	0	1
Sale in Q3-2010	0.06	0.24	0	1
Sale in Q4-2010	0.04	0.21	0	1
Sale in Q1-2011	0.06	0.24	0	1
Sale in Q2-2011	0.07	0.25	0	1
Sale in Q3-2011	0.05	0.23	0	1

Notes: $n = 2{,}580$; [a]sales data for Q2- and Q3-2009 were not available

Table II.
Descriptive statistics for condominium sales

and significant. Specifically, an additional bathroom is associated with a 5.3 percent increase in sales price, an additional bedroom with a 9.9 percent increase and a 100-foot increase in square footage is associated with about a 7.5 percent increase. The neighborhood dummies are all negative and significant suggesting that there is a negative "neighborhood effect" *vis-à-vis* the reference category (Marina District). The "Core" neighborhood – in the central core of the CBD – has the largest negative "neighborhood effect" among those considered here. Perhaps this is due to a lack of residential amenities (e.g. grocery stores) available to residents in this sector of the city. Sales occurring in 2006-2010 all seem to have had larger average sales prices, compared to 2011 (the reference category), with the largest effect in 2007. The regression overall explains approximately 87.5 percent of the variation in the dependent variable.

Variable	Model 1 β	Model 1 t-stat.	Model 2 β	Model 2 t-stat.	Model 3 β	Model 3 t-stat.
Constant	11.80[a]	392.3	11.77[a]	501.0	11.75[a]	477.2
Age	−0.0067*	−12.5	−0.0056*	−13.5	−0.0057*	−13.5
Baths	0.0538*	2.9	0.0465*	3.2	0.0439*	3.0
Bedrooms	0.1064*	7.6	0.0964*	8.9	0.0960*	8.8
Square Footage	0.0009*	45.4	0.0007*	49.7	0.0008*	49.7
Penthouse	0.0416**	2.2	−0.0157	−1.0	–	–
Floor	–	–	0.0215*	38.9	0.0256*	17.0
Floor Squared	–	–	–	–	−0.0001*	−2.9
Columbia	−0.1066*	−6.7	−0.1799*	−14.4	−0.1769*	−14.2
Core	−0.3221*	−12.8	−0.3064*	−15.6	−0.3077*	−15.7
Cortez	−0.2503*	−14.8	−0.1844*	−13.9	−0.1801*	−13.5
East Village	−0.1276*	−8.1	−0.0970*	−7.8	−0.0955*	−7.7
Sale in Q2-2006	0.0642**	2.1	0.0494**	2.1	0.0488**	2.1
Sale in Q3-2006	0.3855*	11.3	0.3701*	13.9	0.3695*	13.9
Sale in Q4-2006	0.3141*	10.9	0.3039*	13.6	0.3045*	13.6
Sale in Q1-2007	0.3784*	14.0	0.3537*	16.7	0.3543*	16.8
Sale in Q2-2007	0.3881*	12.6	0.3596*	15.0	0.3576*	15.0
Sale in Q3-2007	0.4084*	12.4	0.3810*	14.9	0.3808*	14.9
Sale in Q4-2007	0.3842*	12.5	0.3643*	15.2	0.3640*	15.2
Sale in Q1-2008	0.4244*	14.7	0.3297*	14.5	0.3312*	14.6
Sale in Q2-2008	0.2694*	8.6	0.2563*	10.4	0.2558*	10.4
Sale in Q3-2008	0.2314*	7.1	0.2265*	8.9	0.2273*	9.0
Sale in Q4-2008	0.1348*	4.2	0.1389*	5.5	0.1390*	5.6
Sale in Q1-2009	0.1370*	4.1	0.1024*	3.9	0.1046*	4.0
Sale in Q4-2009	0.1079*	3.5	0.0875*	3.7	0.0883*	3.7
Sale in Q1-2010	0.0458	1.5	0.0359	1.5	0.0355	1.5
Sale in Q2-2010	0.0322	1.1	0.0224	1.0	0.0218	1.0
Sale in Q3-2010	0.0586**	2.0	0.0537**	2.4	0.0549**	2.5
Sale in Q4-2010	0.0346	1.1	0.0140	0.6	0.0155	0.6
Sale in Q1-2011	0.0308	1.1	−0.0136	−0.6	−0.0125	−0.5
Sale in Q2-2011	0.0182	0.6	−0.0150	−0.7	−0.0153	−0.7
F stat.	342.5		595.3		597.5	
Adj R^2	0.799		0.878		0.878	
N	2,395		2,395		2,395	

Notes: Significant at: *1, **5 and ***10 percent levels; dependent variable is Ln(Sales Price); reference categories: Marina (neighborhood) and Sale in Q3-2011; Box-Cox transformation estimations also performed; cannot reject the natural log specification at the 5 percent level, so natural log specification maintained and those results reported here

Table III. Semi-log regression estimation results

This is on par with other published results. Note that Model 2, which includes the (very significant) "floor" variable, explains approximately 8 percent more of the variation in the dependent variable than Model 1.

In Model 3, we drop the (insignificant) "penthouse" indicator and add a square of the floor level variable, "floor squared" to see if there are quadratic effects in floor level. Results for Model 3 indicate that the coefficient for "floor squared" is negative and significant, while the "floor" coefficient remains positive and significant. As such, the floor effect appears to be quadratic in price. As floor level increases, the price increases, albeit at a decreasing rate.

So far, the model specifications for estimating the impact of a floor level have only included "penthouse," "floor" or "floor squared." We wish to perform further tests in order to see if the floor effect is monotonically increasing. To do this, we create a piecewise linear spline on the independent variable, "floor," breaking the number of floors into five categories (1-4, 5-8, 9-12, 13-16 and 17-20 floors). These categories express the effect for the specific floor groupings compared to the reference category, namely, higher floors not explicitly controlled for in the model (Table IV).

Results presented in Model 4 indicate that the lowest category (1-4 floors) has a larger negative effect on sales price (−0.290) compared to the next category, 5-8 floors (−0.224). These negative effects are in reference to the omitted category, floors higher than the eighth floor[4]. Does this "lower-floor penalty" persist if we expand the model to include more categories? Results presented in Models 5 and 6 suggest that it does. In Model 6, the effect of a unit being located in the first four floors of a building is −0.461 (compared to units located above 20 floors). This lower-floor penalty declines monotonically in magnitude to a value of −0.146 for the units in floors 17-20. Comparing coefficients for each of the categories, the change in magnitude of the penalty seems to be largest going from "floors 5-8" to "floors 9-12" (the coefficient falls in magnitude from −0.395 to −0.270). Perhaps the ninth floor is just high enough to get a major shift in the trade-off between the negative travel effect and the positive ambience effect. The coefficients for floor categories are shown in Figure 2.

Conclusion

This investigation has been an attempt to investigate the existence of a "higher-floor premium" in condominiums in San Diego, California. In particular, we have attempted to address two major shortcomings of prior investigations; namely that they have been rather narrow geographically (occurring largely in Southeast Asia) and methodologically (including "floor" or "story" as a control, rather than a focus of analysis and without considering a separate "penthouse premium").

Economic theory implies there may be two competing forces affecting the decision to live on higher levels of a condominium building. On one hand, higher-level floors are associated with longer travel times within a given building and hence higher implicit travel costs. However, there may also be positive amenities associated with living higher up such as less traffic noise, better views, etc.

Results presented here generally confirm those of prior investigations. Condominium units located on higher floors are associated with higher-sales prices, controlling for other relevant factors such as square footage, age, neighborhood and year sold. In other words, the positive ambience effect seems to dominate the higher travel costs associated with living on higher floors. With very significant and positive coefficients for "floor" in Models 2 and 3 (and their analogs in Models 4-6), our results support the existence of a higher-floor premium. Specifically, we find that increasing floor level by one (at the mean) is associated with about a 2.2 percent increase in sales price. The floor level effect appears to be quadratic, with the coefficient for floor-squared negative and significant. Thus, higher floors are associated with higher sales prices, though the increase occurs at a decreasing rate.

We do find some evidence for a "penthouse" effect in a simple model without controlling for "floor," though the effect seems to disappear once we include "floor" in the model. In other words, the top-floor does not seem to confer any additional value over and above its advantage of being on a higher floor. When dividing the floors into

Table IV.
Semi-log regression estimation results with floor dummies

Variable	Model 4 β	Model 4 *t*-stat.	Model 5 β	Model 5 *t*-stat.	Model 6 β	Model 6 *t*-stat.
Constant	12.10[a]	341.1	12.14[a]	326.7	12.49[a]	281.9
Age	−0.0076*	−13.6	−0.0064*	−11.3	−0.0116*	−8.9
Baths	0.0019	0.10	0.0369*	1.7	−0.0191	−0.7
Bedrooms	0.138*	9.0	0.1221*	6.9	0.1361*	6.3
Square footage	0.0008*	43.7	0.0008*	40.9	0.0007*	36.0
Floors 1-4	−0.282*	−20.4	−0.350*	−22.6	−0.453*	−22.5
Floors 5-8	−0.2155*	−16.5	−0.2823*	−19.4	−0.3901*	−21.0
Floors 9-12	–	–	−0.1713*	−10.4	−0.2691*	−13.3
Floors 13-16	–	–	–	–	−0.2006*	−9.5
Floors 17-20	–	–	–	–	−0.1449*	−7.1
Columbia	−0.1770*	−10.8	−0.1662*	−10.3	−0.1605*	−9.2
Core	−0.3528*	−11.6	−0.3210*	−10.8	–	–
Cortez	−0.2501*	−12.7	−0.2821*	−13.7	−0.3092*	−13.4
East village	−0.1060*	−5.7	−0.0535*	−2.8	−0.1044*	−4.7
Sale in Q2-2006	0.0332	1.0	0.0415	1.2	0.0116	0.35
Sale in Q3-2006	0.3217*	8.1	0.3257*	8.3	0.2717*	5.5
Sale in Q4-2006	0.2719*	8.0	0.2731*	6.7	0.2818*	5.8
Sale in Q1-2007	0.3030*	10.1	0.2859*	9.4	0.2326*	7.0
Sale in Q2-2007	0.3017*	9.0	0.2877*	8.2	0.2635*	7.2
Sale in Q3-2007	0.3553*	10.1	0.3408*	9.6	0.3562*	8.6
Sale in Q4-2007	0.3455*	11.0	0.3062*	8.9	0.3105*	8.3
Sale in Q1-2008	0.3644*	12.2	0.3534*	11.6	0.3047*	10.0
Sale in Q2-2008	0.2377*	7.2	0.2132*	6.2	0.2620*	7.2
Sale in Q3-2008	0.2222*	6.3	0.2325*	6.3	0.2134*	5.3
Sale in Q4-2008	0.1052*	3.1	0.1076*	3.0	0.1703*	4.3
Sale in Q1-2009	0.1312*	3.8	0.1330*	3.6	0.1372*	3.6
Sale in Q4-2009	0.0995*	3.0	0.1002*	3.0	0.0906*	2.6
Sale in Q1-2010	0.0004	0.01	0.0027	0.08	0.0154	0.42
Sale in Q2-2010	−0.0163	−0.56	−0.0122	−0.41	0.0084	0.25
Sale in Q3-2010	0.0165	0.56	0.0135	0.45	0.0137	0.40
Sale in Q4-2010	0.0208	0.66	0.0254	0.79	0.0024	0.07
Sale in Q1-2011	−0.0190	−0.66	−0.0223	−0.75	−0.0285	−0.91
Sale in Q2-2011	−0.0076	−0.27	−0.0007	−0.03	−0.0158	−0.54
F stat.	332.08		316.54		215.09	
Adj. R^2	0.8493		0.8636		0.8646	
n	1,704		1,496		1,040	

Notes: Significant at: *1, **5 and ***10 percent levels; dependent variable is Ln(Sales Price); reference categories: all floors higher than the highest spline specification in each model, e.g. for Model 4, all floors higher than eighth floor are reference category; Marina (neighborhood); and Sale in Q3-2011; Box-Cox transformation estimations also performed; cannot reject the natural log specification at the 5 percent significance level for Model 4; however, no coefficients changed signs or relative magnitude and only one (Bathrooms) changed significance levels (increased in significance to 5 percent level); cannot reject the natural log specification at the 5 percent significance level for Models 5 or 6 so natural log specification reported here

categories, we find the coefficients for lower floor categories to be more negative than the floors in higher categories. Thus, the higher-floor premium appears to increase monotonically from lower to higher floors. In addition, there appears to be a slightly larger increase in the higher-floor premium moving from the 5-8 floors category to the

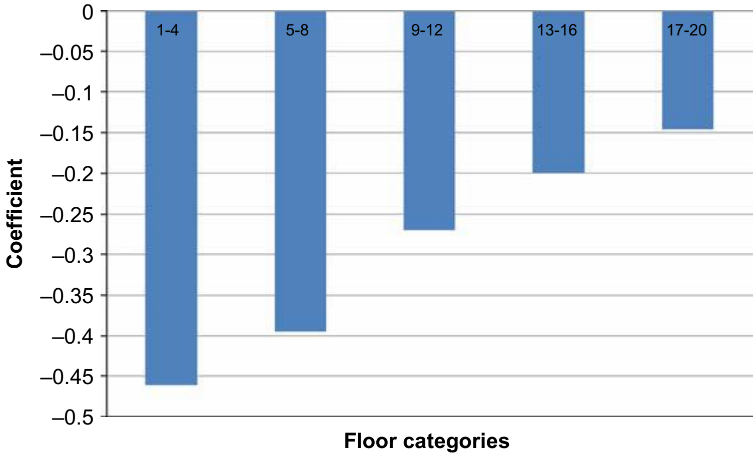

Figure 2.
Coefficient for floor categories, 1-4 through 17-20

9-12 floors category. We speculate that this could be a transition point where the positive ambience effect dominates much more than the negative travel cost effect (moving up from the 5-8 floors to the 9-12 floors category).

While we control for a number of factors affecting sales price and our adjusted R^2 values are in line with other published reports in this area, data limitations prevented us from considering other factors such as noise level (Brandt and Maennig, 2011), average elevator speeds and ocean views (Rodriguez and Sirmans, 1994; Benson *et al.*, 1998). An additional limitation of this study is that San Diego's high-rise condominium market may be lower on average than some other large cities, which could limit the generalizability of this study. We leave these and other issues for future research.

Notes

1. Due to data limitations, we were unable to obtain data for the third and fourth quarters of 2009, though we do not expect those omissions to affect our results. While there were 2,580 condominium sales in the data set, missing values for some of the observations resulted in 2,395 observations used in the regression estimations.
2. However, our mean number of floors is similar to the mean reported for the two Singapore studies referenced above.
3. We interpret the coefficients from the semi-log estimations following Thornton and Innes (1989, p. 444), who suggest that "to calculate the true proportional change in Y resulting from a non-infinitesimal change in X, one would have to calculate: $g = \exp(b\Delta X) - 1$." See also, Halvorsen and Palmquist (1980) for a related discussion on interpretation of dummy variables.
4. Only observations for which there were more than eight floors were included in this estimation, which is why the number of observations has fallen to 898.

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