Residential Real Estate, Risk, Return and the Benefits of Diversification: Some Empirical Evidence

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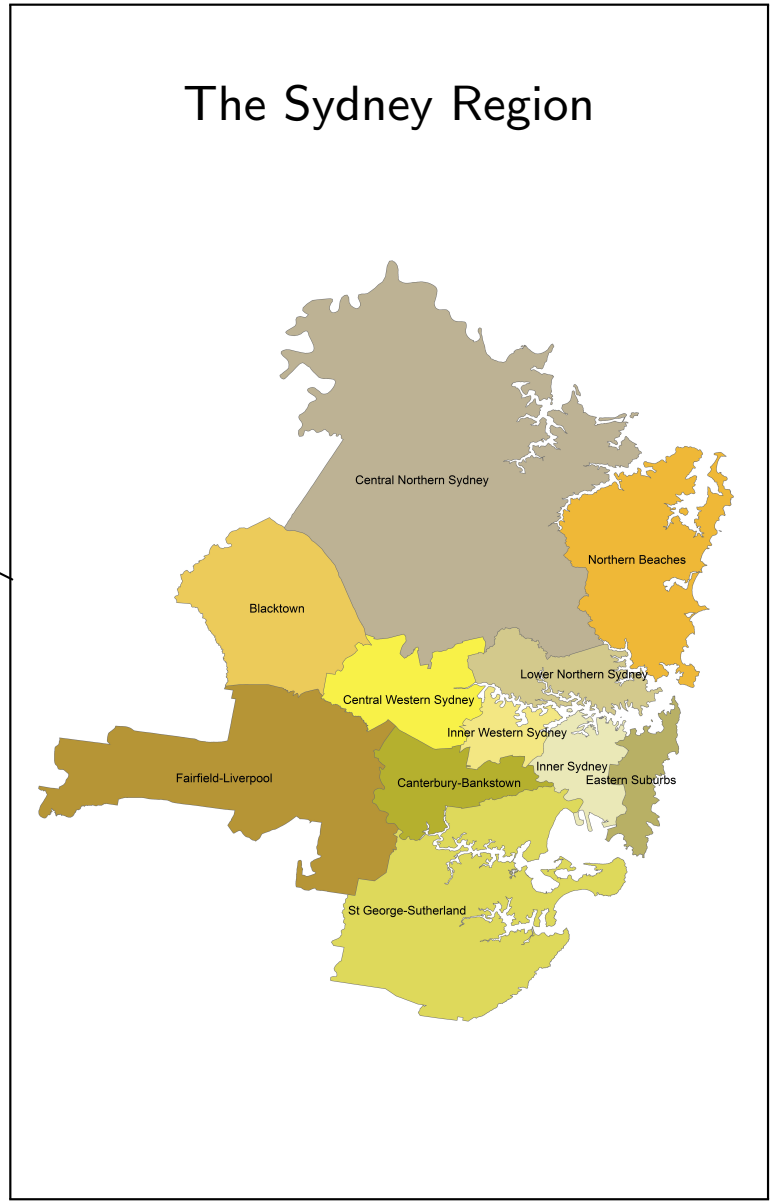
1. Introduction

- The objective of the paper is to investigate the financial properties of residential real estate investment in indivdual homes:
  - Total returns and risk.
  - The benefits of diversification.
- The main contributions of the paper are:
  - Methodological: illustrate how to construct total returns—price appreciation and rental yield—at the level of the individual property.
  - Empirical: results and contrast of housing with equities.

2. Sydney Housing and Equity Data

- Housing data for Sydney, Australia:
  - Home sales prices and characteristics from 2000Q1-2014Q4.
    - 549,504 observations (435,501 unique homes).
  - Home rents and characteristics from 2002Q1-2014Q4.
    - 1,143,534 observations (436,130 unique homes).
  - Characteristics include:
    - property type (house or apartment).
    - land area (for houses).
    - number or bedrooms and bathrooms.
    - location (region, postcode, latitude and longitude).
- Equity data:
  - Total returns (capital gain + dividends) for the 200 largest companies listed on the Australian Stock Exchange from 2002Q1-2014Q4.

2. Sydney Housing and Equity Data



3. Hedonic Estimation

The plan:

- Develop hedonic models of prices and rents.
- Impute prices and rents for a random sample of 10,000 properties.
- Calculate total returns—the sum of the capital gain and rent.
  - We assume a home is rented out for 50 of 52 possible weeks a year.
  - We also net off 'running costs' which we suppose are 2.5% per year (Harding, Rosenthal and Sirmans, 2007).
- Analyse these imputed total returns series.

3. Hedonic Estimation

- A general hedonic model (for prices or rents) can be written as:

$$\ln p_{it} = \tau_{i[r]t} + \sum_{c=1}^{C} f(z_{i[r]tc}) + \epsilon_{it}, \qquad t = 1, 2, ..., T, \; i = 1, 2, ..., I$$

- Here the indexes are: c=characteristics, i=property, t=time, r=region. The $z_{i[r]tc}$ denotes the value of a certain characteristic.
- This equation nests many common models:
  - Time-Dummy: $\tau_{i[r]t} = \tau_t$ and $f(z_{i[r]tc}) = \delta_c z_{i[r]tc}$
  - Time-Region Dummy: $\tau_{i[r]t} = \tau_{rt}$ and $f(z_{i[r]tc}) = \delta_c z_{i[r]tc}$
  - Time Flexible: $f(z_{i[r]tc}) = \delta_{ct} z_{i[r]tc}$
  - Time-Region Flexible: $f(z_{i[r]tc}) = \delta_{crt} z_{i[r]tc}$ and $\tau_{i[r]t} = \tau_{rt}$

3. Hedonic Estimation

- We take a flexible approach that uses penalised smoothing splines:

$$\begin{aligned}\ln p_{it} = {} & s_1(bedrooms, t, lat, long) + s_2(bathrooms, t, lat, long) \\ & + s_3([apartment][house], t, lat, long) + s_4(land\ area, t, lat, long) \\ & + s_5(t, lat, long) + \epsilon_{it}, \qquad t = 1, 2, ..., T,\ i = 1, 2, ..., I\end{aligned}$$

- Here the $s(.)$ denotes a smooth function of the variables included.

- The Generalized Cross Validation (GCV) approach is used to choose the degree of smoothing.

3. Hedonic Estimation

Table: Hedonic Model Fit Statistics

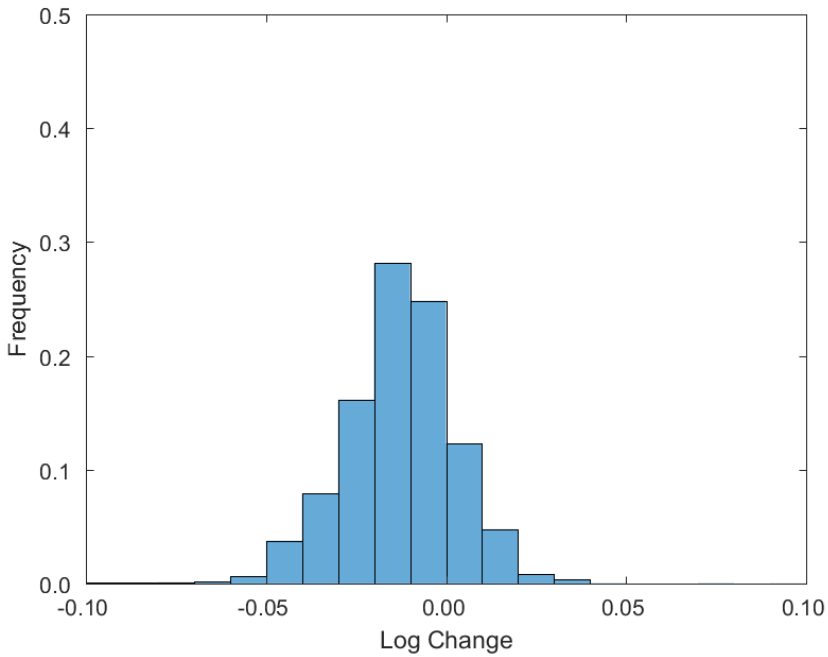
	Time Smooth	Time-Spatial Smooth	Time-Dummy (τ_t,δ_c)	Time-Region Dummy (τ_{rt},δ_c)	Time Flexible (τ_{rt},δ_{tc})	Region Flexible (τ_{rt},δ_{rc})	Time-Region Flexible (τ_{rt},δ_{rtc})
				Home Sale Prices			
No. Obs.	549,504	549,504	549,504	549,504	549,504	549,504	549,468
No. Parms.	701	2,450	74	664	900	704	3,223
AIC	35,005	-24,001	264,959	260,537	246,426	188,010	177,374
R^2	0.7950	0.8171	0.6878	0.6909	0.6940	0.7079	0.7129
RMSE	0.2495	0.2357	0.3079	0.3063	0.3048	0.2978	0.2953
MAE	0.1785	0.1667	0.2253	0.2238	0.2226	0.2164	0.2147
				Home Rents			
No. Obs.	1,143,534	1,143,534	1,143,534	1,143,534	1,143,534	1,143,534	1,143,531
No. Parms.	814	2,505	65	564	764	604	2,792
AIC	-368,203	-439,825	33,877	24,253	-5,713	-126,763	-154,874
R^2	0.7692	0.7839	0.6716	0.6746	0.6769	0.6887	0.6919
RMSE	0.2058	0.1992	0.2456	0.2444	0.2436	0.2391	0.2379
MAE	0.1501	0.1438	0.1797	0.1787	0.1780	0.1743	0.1733

Note: No. Obs.=number of observations used in the estimation, No. Parms.=number of parameters in the model (or equivalent in the smoothing splines), R^2= the squared correlation coefficient between estimated and actual log prices, RMSE=Root Mean Squared Error, MAE=Mean Absolute Error, AIC=Akaike Information Criterion.

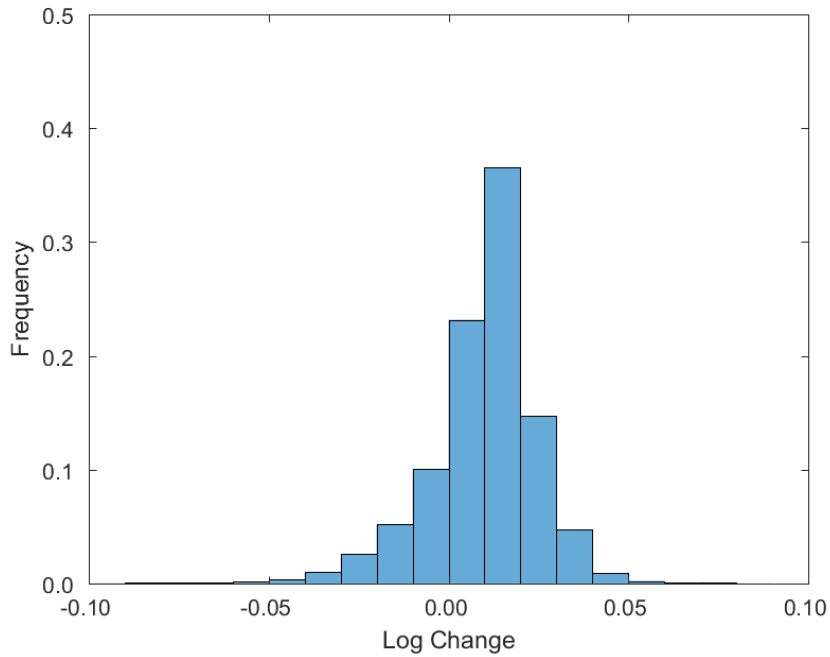
3. Hedonic Estimation

Figure: Histogram of Log Price Change
(All Homes)

2008Q3

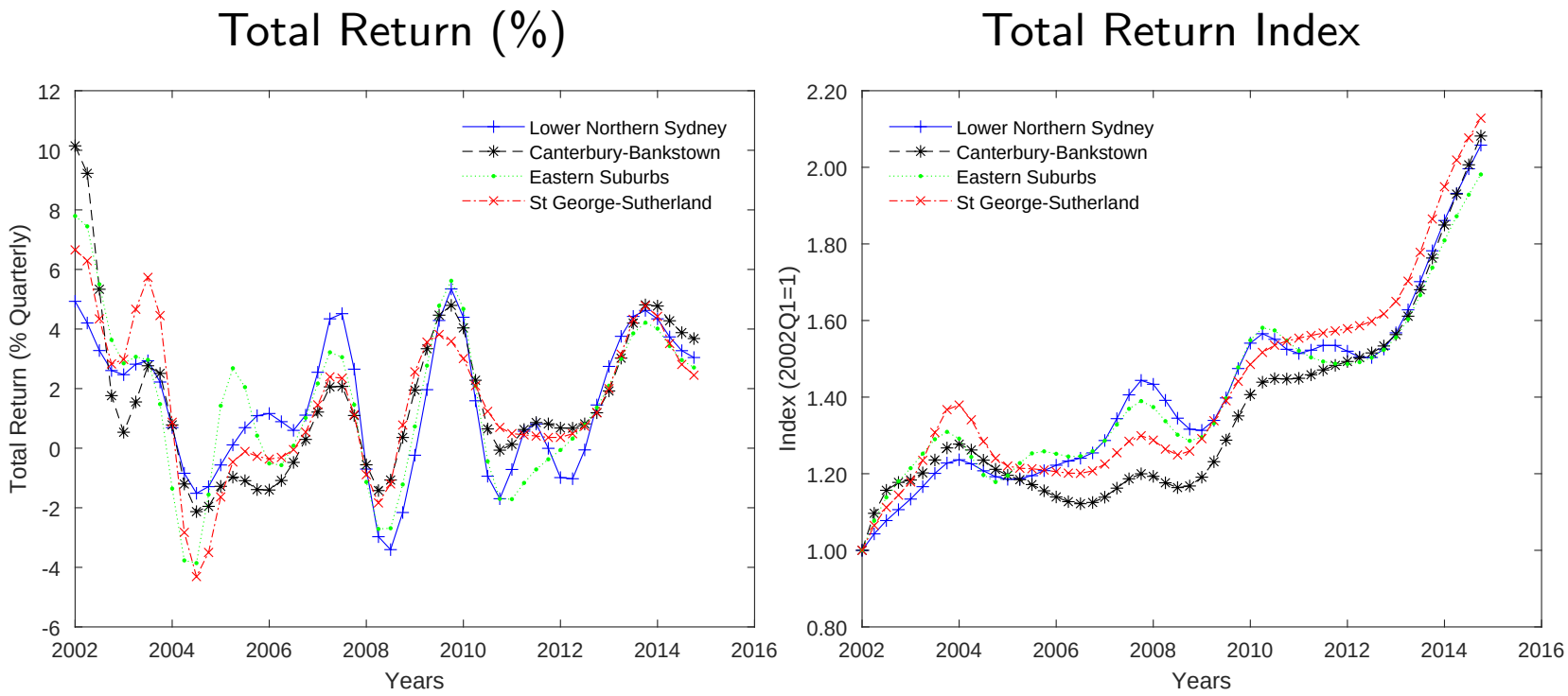


2010Q3



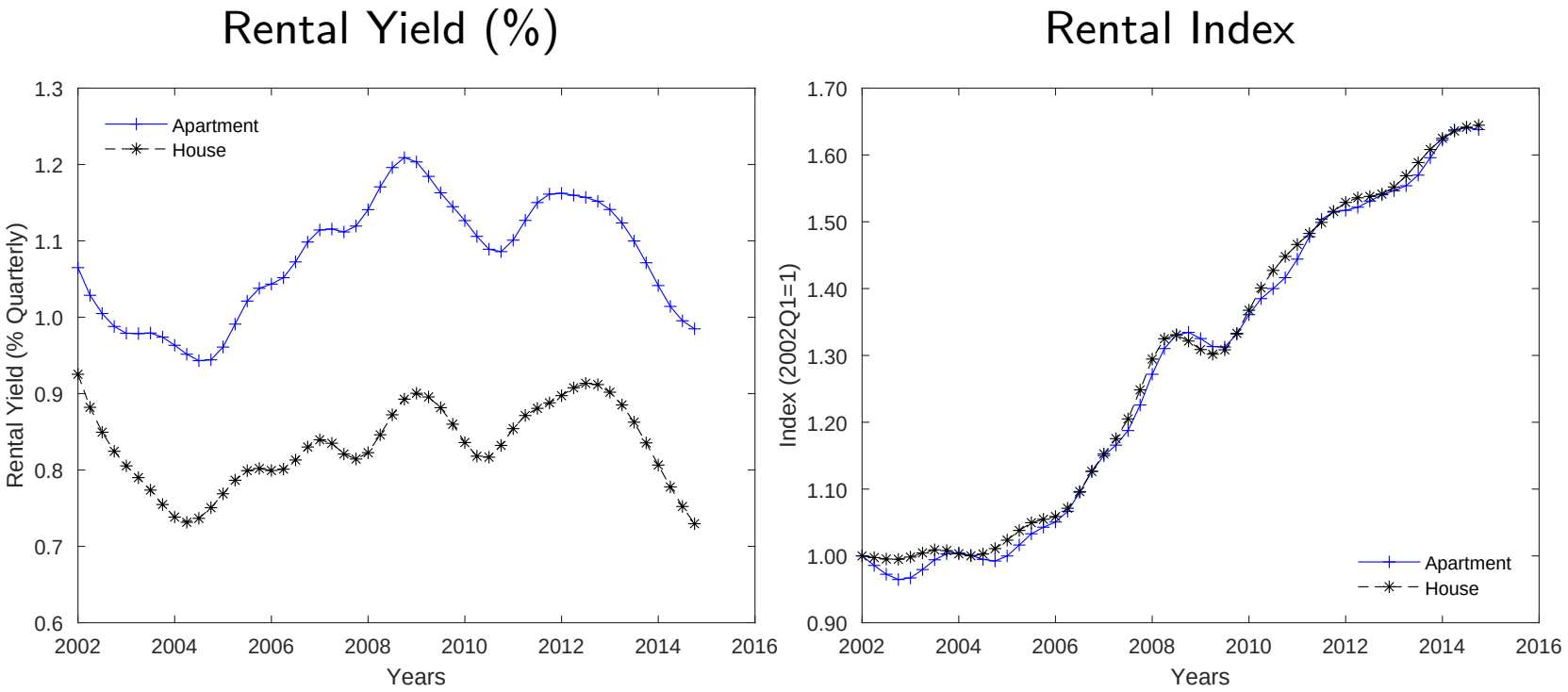
3. Hedonic Estimation

Figure: Comparing Houses Across Regions
(Mean for: House=1, Bedrooms=3, Bathrooms=2, Land Area $\in$ [400,1000])



3. Hedonic Estimation

Figure: Comparing Houses and Apartments
(Mean for: Bedrooms $\in$ [1,4], Bathrooms $\in$ [1,2], Region=Lower Northern Sydney)



4. Housing Risk, Return and Diversification

- In examining risk, return and diversification we make extensive use of the Sharpe ratio (a measure of risk-adjusted return):

$$SR_i = \frac{\bar{R}_i - \bar{R}_f}{\sigma_{if}}$$

Table: The Distribution of Total Returns and the Sharpe Ratios (Quarterly)

		Housing	Shares
No. Obs		10,000	200
		Total Returns (%)	
Mean		1.74	4.45
Percentiles:	5th	1.20	0.77
	25th	1.54	2.52
	50th	1.74	3.59
	75th	1.95	5.40
	95th	2.33	10.43
		Sharpe Ratio	
Mean		0.2294	0.1573
Percentiles:	5th	0.0213	-0.0173
	25th	0.1470	0.0882
	50th	0.2344	0.1475
	75th	0.3085	0.2281
	95th	0.4275	0.3562

4. Housing Risk, Return and Diversification

Variable	Total Returns		Std. Dev. Total Returns		Sharpe Ratio	
	[A]	[B]	[A]	[B]	[A]	[B]
Dwelling Type						
Apartment	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
House	0.0012***	0.0024***	0.0005***	0.0000***	0.0144***	0.0413***
	(0.0003)	(0.0003)	(0.0004)	(0.0003)	(0.0037)	(0.0039)
Region						
Blacktown	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Canterbury-Bankstown	-0.0010	0.0008	-0.0163***	-0.0003***	0.0346***	0.0296***
	(0.0007)	(0.0005)	(0.0013)	(0.0006)	(0.0068)	(0.0071)
Central Northern Sydney	-0.0017**	0.0032***	-0.0224***	-0.0029***	0.0513***	0.1750***
	(0.0007)	(0.0005)	(0.0012)	(0.0006)	(0.0062)	(0.0067)
Central Western Sydney	-0.0007	0.0012**	-0.0170***	-0.0003***	0.0434***	0.0562***
	(0.0007)	(0.0005)	(0.0013)	(0.0006)	(0.0066)	(0.0068)
Eastern Suburbs	-0.0048***	0.0040***	-0.0181***	0.0019***	-0.0874	0.1624***
	(0.0007)	(0.0006)	(0.0012)	(0.0007)	(0.0065)	(0.0085)
Fairfield-Liverpool	0.0026***	0.0007	-0.0039	0.0022***	0.0412	-0.0543***
	(0.0008)	(0.0005)	(0.0017)	(0.0008)	(0.0068)	(0.0069)
Inner Sydney	-0.0019***	0.0050***	-0.0223***	-0.0005***	0.0904***	0.2603***
	(0.0007)	(0.0005)	(0.0012)	(0.0007)	(0.0062)	(0.0076)
Inner Western Sydney	-0.0046***	0.0022***	-0.0188***	0.0019***	-0.0688	0.1177***
	(0.0007)	(0.0005)	(0.0012)	(0.0007)	(0.0067)	(0.0079)
Lower Northern Sydney	-0.0041***	0.0039***	-0.0224***	-0.0011***	-0.0310***	0.2034***
	(0.0007)	(0.0005)	(0.0012)	(0.0007)	(0.0064)	(0.0081)
Northern Beaches	-0.0044***	0.0027***	-0.0190***	-0.0007***	-0.0396	0.1571***
	(0.0007)	(0.0005)	(0.0012)	(0.0007)	(0.0066)	(0.0078)
St George-Sutherland	-0.0042***	0.0005	-0.0162***	0.0001***	-0.0744*	0.0388***
	(0.0007)	(0.0005)	(0.0012)	(0.0006)	(0.0061)	(0.0068)
Land Area						
Apartment	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
House	-0.0013***	-0.0013***	0.0083***	0.0061***	-0.0765***	-0.0698***
	(0.0003)	(0.0003)	(0.0004)	(0.0004)	(0.0027)	(0.0028)
No. Bedrooms	-0.0004***	0.0015***	0.0000***	0.0001***	-0.0069***	0.0557***
	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0014)	(0.0018)
Log Price Level (in 2002)	—	-0.0084***	—	0.0012***	—	-0.3082***
	—	(0.0003)	—	(0.0004)	—	(0.0048)
Total Return (in 2002)	—	-0.0369***	—	—	—	—
	—	(0.0045)	—	—	—	—
Std. Dev. TR (in 2002)	—	—	—	0.1169***	—	—
	—	—	—	(0.0064)	—	—
Sharpe Ratio (in 2002)	—	—	—	—	—	0.0014***
	—	—	—	—	—	(0.0003)
Constant	0.0208***	0.1189***	0.0403***	0.0015***	0.2816***	3.9301***
	(0.0007)	(0.0041)	(0.0013)	(0.0049)	(0.0065)	(0.0554)

4. Housing Risk, Return and Diversification

- There appears to be a systematic relationship between home characteristics, total returns, the standard deviation of total returns, and the Sharpe ratio:
  - Houses have higher total returns, and a higher Sharpe ratio, than do apartments.
  - Region explains a lot of the variation in total returns.
  - Homes which are larger—bigger land area and more bedrooms—have had somewhat weaker returns.
  - Higher priced homes have experienced lower total returns.

4. Housing Risk, Return and Diversification

- We examine how the Sharpe ratio changes for different-sized portfolios of homes and shares.

Table: Sharpe Ratio and Portfolio Size

	Portfolio Size†							
	1	2	5	10	20	50	100	200
Homes	0.1977	0.2125	0.2254	0.2329	0.2378	0.2511	0.2542	0.2558
	(0.1486)	(0.1336)	(0.1060)	(0.0779)	(0.0618)	(0.0412)	(0.0283)	(0.0198)
Shares	0.1614	0.1885	0.2328	0.2728	0.2894	0.3095	0.3181	0.3214
	(0.1200)	(0.1031)	(0.0809)	(0.0603)	(0.0479)	(0.0301)	(0.0181)	(0.0000)

†Note: The mean Sharpe ratio is shown with its standard error in brackets.

4. Housing Risk, Return and Diversification

- We undertake portfolio optimisation looking at the benefits of having access to a portfolio of homes compared with a single home.

Table: Portfolio Weights and Utility Gain

	$\gamma = 4$			
	[A]	[B]	[C]	[D]
Portfolio Weights (%)				
Individual Homes	36.20	25.19	—	—
Aggregate Homes	—	16.82	85.00	37.33
Individual Shares	—	—	15.00	7.09
Aggregate Shares	61.74	57.98	—	55.59
Risk Free Asset	2.06	0.00	0.00	0.00
Utility Gain (%)†		0.03		0.41

† This compares the utility from [B] vs [A] and from [D] vs [C].

5. Conclusion

- It is possible to construct estimates of the total return to owning an individual home using flexible spline smoothing hedonic models.
- The Sharpe ratio for individual homes has been higher than that for individual shares.
    - Individual homes are much lower risk than individual shares.
- There is significant dispersion in the returns to housing which are explainable by the charactristics of the home.
- The benefits to homeowners of a diversified portfolio are fairly modest, at least compared with shares.