

Internet Appendix
For
Outshine to Outbid: Weather-Induced Sentiment and the Housing Market

Maggie Rong Hu¹ and Adrian D. Lee

This Internet Appendix reports the results of supplementary and robustness tests as described below:

Figure IA1: Example of Subdivision Advertisement	2
Table IA1: Day of the Week of Real Estate Subdivision Auctions in Sydney 1833 to 1983.....	3
Table IA2: Sentiment and Housing Prices Using Weather Prior to Transaction.....	4
Panel A: Using Lagged 1 Day Weather.....	4
Panel B: Using Moving Average $t-1$ to $t-3$ Day Weather.....	5
Panel C: Using Moving Average $t-1$ to $t-7$ Day Weather.....	6
Table IA3: Sentiment in Housing Auctions using Suburb/YQ Fixed Effects	7
Panel A: Sentiment Regressions using the Entire Sample.....	7
Panel B: Sentiment Regressions using the Auction Sales Sample	8
Panel C: Sentiment Regressions using the Private Negotiation Sales Sample	8
Table IA4: Sentiment in Housing Auctions Using De-seasoned and Standardized Sentiments	9
Panel A: Sentiment Regressions using Full Sample.....	9
Panel B: Sentiment Regressions using Auction Sales Sample	10
Panel C: Sentiment Regressions using the Private Negotiation Sales Sample	10
Table IA5: Housing Market Dispersion on Auction Price	11

¹ Any queries on the content of this Internet Appendix could be directed to the corresponding author Maggie Hu. Email: maggiuhu@cuhk.edu.hk; Tel: (852) 3943-8592. Correspondence address: Room 710, Cheng Yu Tung Building, No.12, Chak Cheung Street, Shatin, New Territories, Hong Kong Chinese University of Hong Kong.

Figure IA1: Example of Subdivision Advertisement

This figure is a subdivision advertisement from the New South Wales State Library Subdivision Plans significant collection, available online. It advertises land subdivisions in the suburb of Northbridge in Sydney's Lower North Shore. The sale is by auction on the grounds, wet or fine, on Saturday, February 26th, 1927 at 3:15pm.

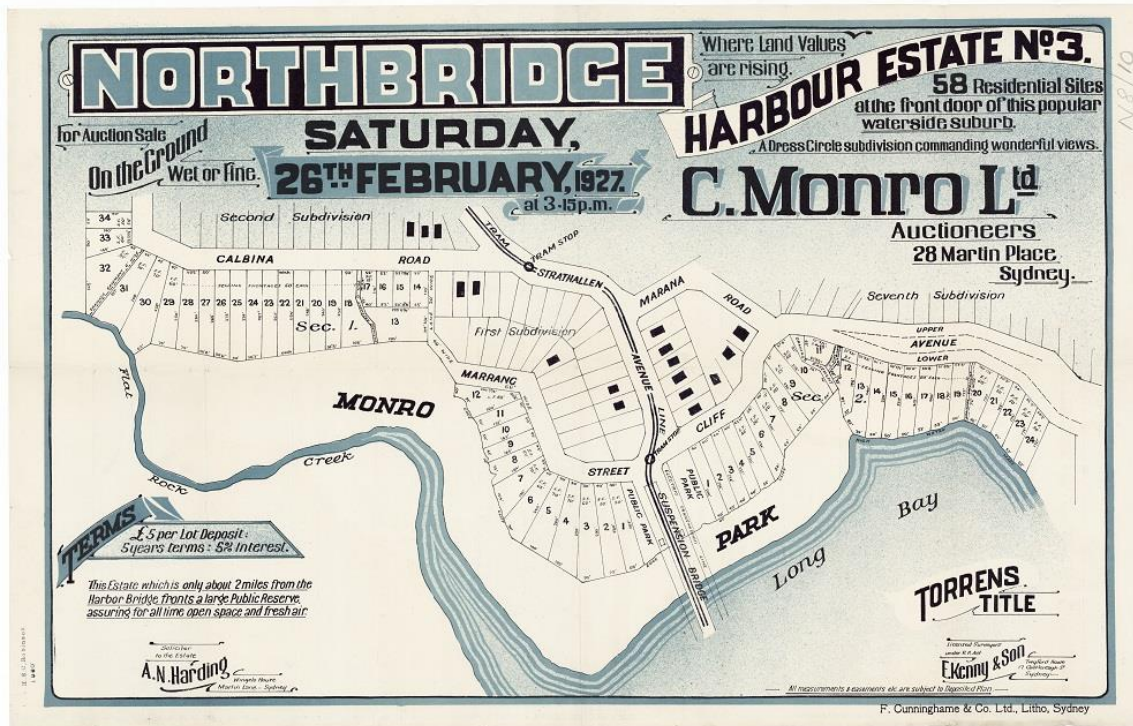


Table IA1: Day of the Week of Real Estate Subdivision Auctions in Sydney 1833 to 1983

This table reports the frequency of historical land subdivision auction dates by day of the week. We collect records of posters advertising new land subdivision sales in Sydney from the New South Wales State Library Subdivision Plans significant collection (<https://www.sl.nsw.gov.au/research-and-collections/significant-collections/subdivision-plans>). The advertisements primarily describe auctions, particularly if the record contains a date or day. Each record contains the call number, title, boundaries, and date. We remove duplicates, records without a day of the week, and records that are not subdivision advertisements such as diagrams, letters, prices lists and sketches.

Years	Mon	Tue	Wed	Thu	Fri	Sat	Sun	All Days
<i>Historical Sample</i>								
No Year	55	50	55	45	65	1,076	0	1,346
1833 to 1900	142	84	156	105	112	1,737	0	2,336
1901 to 1950	278	90	168	143	207	5,526	0	6,412
1951 to 1983	2	7	3	4	6	49	0	71
All Years	477	231	382	297	390	8,388	0	10,165
%	4.69%	2.27%	3.76%	2.92%	3.84%	82.52%	0.00%	100%
<i>Our Sample</i>								
Auction	3,873	10,277	13,940	14,713	1,784	89,446	1,089	135,122
%	2.87%	7.61%	10.32%	10.89%	1.32%	66.20%	0.81%	100.00%
Private Sale	109,640	112,615	112,295	113,632	159,752	57,436	21,055	686,425
%	15.97%	16.41%	16.36%	16.55%	23.27%	8.37%	3.07%	100.00%

Table IA2: Sentiment and Housing Prices Using Weather Prior to Transaction

This table reports coefficient estimates for the following hedonic model across the full sample of individual housing prices:

$$\ln(P_{ist}) = \alpha_0 + \beta_1 MAWeather_{t-1,t-l} + \beta_2 Auction_i + \beta_3 Auction_i * MAWeather_{t-1,t-l} + property\ char_i + \mu_s + \gamma_t + \varepsilon_{it}$$

Where $\ln(P_{ist})$ denotes the natural logarithm of housing price for sale i in suburb s at time t ; $Auction$ is a dummy of 1 if the home is sold at auction, 0 otherwise; $MAWeather_{t-1,t-l}$ is the lagged moving average from $t-1$ to $t-l$ ($l=1,3,7$) of one of the three sentiment measures for a home sold at time t ; $property\ char$ are various property characteristics such as number of bedrooms, number of bathrooms, parking, property type, and area size; μ_s is the suburb location specific fixed effects; and γ_t are year and quarter fixed effects. The three weather measures are *Rain*, *Solar*, and *Temp*. *Rain* is the amount of rain in millimetres for the transaction day. *Solar* is the amount of solar exposure for the transaction day. *Temp* is the maximum temperature in degrees Celsius for the transaction day. Coefficient estimates of sentiment measures and their interactions are multiplied by 1000 for display purposes. Other variables are described in Appendix 1. The sample is home sales in the Sydney metropolitan area from 2000 to 2014. Standard errors are denoted in parentheses. ***, **, * signifies statistical significance at the 1, 5, and 10 percent level, respectively. Panel A uses the full sample using lagged 1 day weather, Panels B uses lagged 3 day moving average weather and Panel C uses lagged 7 day moving average weather.

Panel A: Using Lagged 1 Day Weather

Variables	(1) log(price)	(2) log(price)	(3) log(price)
Auction	0.070*** (0.003)	0.061*** (0.003)	0.061*** (0.005)
Rain _{t-1}	-0.103*** (0.028)		
Auction*Rain _{t-1}	-0.313*** (0.109)		
Solar _{t-1}		-0.021 (0.043)	
Auction*Solar _{t-1}		0.537*** (0.099)	
Temp _{t-1}			0.181** (0.086)
Auction*Temp _{t-1}			0.390** (0.193)
Constant	3.663*** (0.468)	3.226*** (0.473)	3.713*** (0.469)
Housing Char.	Yes	Yes	Yes
Suburb F.E.	Yes	Yes	Yes
Monthly Time Trend	Yes	Yes	Yes
Year and Quarter F.E.	Yes	Yes	Yes
Cluster S.E.	Suburb	Suburb	Suburb
N	821,547	806,377	821,547
Adj Rsq	0.840	0.841	0.840

Panel B: Using Moving Average $t-1$ to $t-3$ Day Weather

Variables	(1) log(price)	(2) log(price)	(3) log(price)
Auction	0.070*** (0.003)	0.058*** (0.003)	0.057*** (0.006)
Rain _{t-1,t-3}	-0.195*** (0.042)		
Auction*Rain _{t-1,t-3}	-0.221 (0.140)		
Solar _{t-1,t-3}		0.005 (0.063)	
Auction*Solar _{t-1,t-3}		0.707*** (0.117)	
Temp _{t-1,t-3}			0.273** (0.124)
Auction*Temp _{t-1,t-3}			0.569*** (0.210)
Constant	3.656*** (0.468)	3.239*** (0.473)	3.710*** (0.467)
Housing Char.	Yes	Yes	Yes
Suburb F.E.	Yes	Yes	Yes
Monthly Time Trend	Yes	Yes	Yes
Year and Quarter F.E.	Yes	Yes	Yes
Cluster S.E.	Suburb	Suburb	Suburb
N	821,547	806,377	821,547
Adj Rsq	0.840	0.841	0.840

Panel C: Using Moving Average $t-1$ to $t-7$ Day Weather

Variables	(1) log(price)	(2) log(price)	(3) log(price)
Auction	0.070*** (0.003)	0.056*** (0.003)	0.052*** (0.006)
Rain _{t-1,t-7}	-0.338*** (0.060)		
Auction*Rain _{t-1,t-7}	-0.310* (0.173)		
Solar _{t-1,t-7}		0.067 (0.086)	
Auction*Solar _{t-1,t-7}		0.829*** (0.122)	
Temp _{t-1,t-7}			0.339** (0.151)
Auction*Temp _{t-1,t-7}			0.771*** (0.234)
Constant	3.589*** (0.468)	3.259*** (0.471)	3.714*** (0.466)
Housing Char.	Yes	Yes	Yes
Suburb F.E.	Yes	Yes	Yes
Monthly Time Trend	Yes	Yes	Yes
Year and Quarter F.E.	Yes	Yes	Yes
Cluster S.E.	Suburb	Suburb	Suburb
N	821,547	806,377	821,547
Adj Rsq	0.840	0.841	0.840

Table IA3: Sentiment in Housing Auctions using Suburb/YQ Fixed Effects

This table follows the specifications of Table 3, except it uses Suburb and Year/Quarter Fixed Effects and clustered standard errors at the Suburb level by Year/Quarter. All sentiment measures are standardized by subtracting the sample average and dividing by the sample standard deviation. Coefficient estimates of sentiment measures and their interactions are multiplied by 1000 for display purposes. Standard errors are denoted in parentheses. ***, **, * signifies statistical significance at the 1, 5, and 10 percent level, respectively. Panel A presents the result using the full sample, while Panels B and C use the auction sale sample and private negotiation sample, respectively.

Panel A: Sentiment Regressions using the Entire Sample

Variables	(1) log(price)	(2) log(price)	(3) log(price)	(4) log(price)
SurveySenti	-0.712 (0.650)			
Auction*SurveySen	11.278*** (1.053)			
Rain		-0.321 (0.295)		
Auction*Rain		-2.633*** (0.792)		
Solar			-0.581* (0.351)	
Auction*Solar			5.451*** (0.930)	
Temp				0.305 (0.372)
Auction*Temp				3.297*** (0.906)
Auction	0.065*** (0.001)	0.065*** (0.001)	0.065*** (0.001)	0.065*** (0.001)
Constant	3.363*** (0.467)	3.361*** (0.465)	3.088*** (0.469)	3.418*** (0.465)
Housing Char.	Yes	Yes	Yes	Yes
Suburb/YQ F.E.	Yes	Yes	Yes	Yes
Monthly Time	Yes	Yes	Yes	Yes
Cluster S.E.	Suburb/YQ	Suburb/YQ	Suburb/YQ	Suburb/YQ
N	821,547	821,547	806,377	821,547
Adj Rsq	0.848	0.848	0.849	0.848

Panel B: Sentiment Regressions using the Auction Sales Sample

Variables	(1) log(price)	(2) log(price)	(3) log(price)	(4) log(price)
SurveySenti	0.013 (1.923)			
Rain		-3.073*** (0.817)		
Solar			3.150*** (1.083)	
Temp				2.040** (1.040)
Constant	1.544 (1.427)	1.391 (1.427)	0.909 (1.451)	1.600 (1.429)
Housing Char.	Yes	Yes	Yes	Yes
Suburb/YQ F.E.	Yes	Yes	Yes	Yes
Monthly Time	Yes	Yes	Yes	Yes
Cluster S.E.	Suburb/YQ	Suburb/YQ	Suburb/YQ	Suburb/YQ
N	135,122	135,122	132,400	135,122
Adj Rsq	0.806	0.806	0.807	0.806

Panel C: Sentiment Regressions using the Private Negotiation Sales Sample

Variables	(1) log(price)	(2) log(price)	(3) log(price)	(4) log(price)
SurveySenti	1.262* (0.678)			
Rain		-0.318 (0.296)		
Solar			-0.448 (0.352)	
Temp				0.522 (0.375)
Constant	3.841*** (0.497)	3.772*** (0.494)	3.553*** (0.498)	3.776*** (0.494)
Housing Char.	Yes	Yes	Yes	Yes
Suburb/YQ F.E.	Yes	Yes	Yes	Yes
Monthly Time	Yes	Yes	Yes	Yes
Cluster S.E.	Suburb/YQ	Suburb/YQ	Suburb/YQ	Suburb/YQ
N	686,425	686,425	673,977	686,425
Adj Rsq	0.848	0.848	0.849	0.848

Table IA4: Sentiment in Housing Auctions Using De-seasoned and Standardized Sentiments

This table follows Table 3 except that sentiment measures are de-seasoned and standardized. Sentiment measures are de-seasoned by subtracting the average daily measures over the past three years for the same month. De-seasoning removes potential trends in the sentiment variables. The de-seasoned measures are then standardized by subtracting the sample average and dividing by the sample standard deviation. Coefficient estimates of sentiment measures and their interactions are multiplied by 1000 for display purposes. Standard errors are denoted in parentheses. ***, **, * signifies statistical significance at the 1, 5, and 10 percent level, respectively. Panel A presents the result using the full sample, while Panels B and C use the auction sale sample and private negotiation sample, respectively.

Panel A: Sentiment Regressions using Full Sample

Variables	(1) log(price)	(2) log(price)	(3) log(price)	(4) log(price)
SurveySenti	9.910*** (0.435)			
Auction*SurveySenti	4.106*** (1.016)			
Rain		-0.924*** (0.298)		
Auction*Rain		-1.164 (0.758)		
Solar			0.535* (0.288)	
Auction*Solar			5.706*** (0.890)	
Temp				1.282*** (0.295)
Auction*Temp				0.868 (0.810)
Auction	0.069*** (0.003)	0.070*** (0.003)	0.069*** (0.003)	0.069*** (0.003)
Constant	3.645*** (0.468)	3.649*** (0.467)	1.909*** (0.488)	3.670*** (0.468)
Housing Char.	Yes	Yes	Yes	Yes
Suburb F.E.	Yes	Yes	Yes	Yes
Monthly Time Trend	Yes	Yes	Yes	Yes
Year Quarter F.E.	Yes	Yes	Yes	Yes
Cluster S.E.	Suburb	Suburb	Suburb	Suburb
N	821,547	821,547	793,326	821,547
Adj Rsq	0.840	0.840	0.841	0.840

Panel B: Sentiment Regressions using Auction Sales Sample

Variables	(1) log(price)	(2) log(price)	(3) log(price)	(4) log(price)
SurveySenti	12.573*** (1.010)			
Rain		-2.697*** (0.676)		
Solar			5.109*** (0.754)	
Temp				2.672*** (0.716)
Constant	1.390 (1.156)	1.512 (1.144)	-1.012 (1.179)	1.710 (1.150)
Housing	Yes	Yes	Yes	Yes
Suburb F.E.	Yes	Yes	Yes	Yes
Monthly Time	Yes	Yes	Yes	Yes
Year Quarter	Yes	Yes	Yes	Yes
Cluster S.E.	Suburb	Suburb	Suburb	Suburb
N	135,122	135,122	130,178	135,122
Adj Rsq	0.796	0.796	0.796	0.796

Panel C: Sentiment Regressions using the Private Negotiation Sales Sample

Variables	(1) log(price)	(2) log(price)	(3) log(price)	(4) log(price)
SurveySenti	10.110*** (0.431)			
Rain		-0.805*** (0.296)		
Solar			0.512* (0.287)	
Temp				1.075*** (0.295)
Constant	4.052*** (0.521)	4.014*** (0.522)	2.460*** (0.530)	4.016*** (0.522)
Housing	Yes	Yes	Yes	Yes
Suburb F.E.	Yes	Yes	Yes	Yes
Monthly	Yes	Yes	Yes	Yes
Year Quarter	Yes	Yes	Yes	Yes
Cluster S.E.	Suburb	Suburb	Suburb	Suburb
N	686,425	686,425	663,148	686,425
Adj Rsq	0.839	0.839	0.840	0.839

Table IA5: Housing Market Dispersion on Auction Price

This table estimates the effect of dispersion or uncertainty on auction price. We estimate a hedonic model including auction in addition to the lagged quarterly housing survey-based dispersion and sentiment measures, using the auction sale sample as follows:

$$\ln(P_{ist}) = \alpha_0 + \beta_1 Disp_t + \beta_2 Sentiment_t + \beta_3 Disp_t * Sentiment_t + property\ char_i + \mu_s + \gamma_t + \varepsilon_{it}$$

The sample is home sales in the Sydney metropolitan area from July 2009 to December 2014. Quarterly housing price expectations survey data for New South Wales is sourced from the Melbourne Institute, and it starts from 2009 too. Every quarter, survey respondents are asked about their views on house price movements in the next twelve months. We measure house price uncertainty by the standard deviation of responses in the prior quarter as:

$$Disp_t = \sqrt{\frac{\sum_{i=1}^5 w_{it} (x_{it} - \bar{x}_t)^2}{\sum_{i=1}^5 w_{it}}} \text{ with } \bar{x}_t = (\sum_{i=1}^5 w_{it} x_{it}) / \sum_{i=1}^5 w_{it}$$

where w_{it} is the weight of responses in each of the five categories (more than 10% fall, between -10% and 0, 0, between 0 and 10% increase, and more than 10% increase) in quarter t . x_{it} is the values assigned to each category (from -2 to 2 with more than 10% fall assigned with a value of -2, between -10% and 0 assigned a value of -1, etc.). \bar{x}_t^* is the weighted mean of responses. All sentiment measures and $Disp_t$ are standardized by subtracting the sample average and dividing by the sample standard deviation. ***, **, * signifies statistical significance at the 1, 5, and 10 percent level, respectively.

Variables	(1) log(price)	(3) log(price)	(4) log(price)	(5) log(price)	(6) log(price)
Disp	0.003** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.003** (0.001)	0.003** (0.001)
SurveySenti		6.960*** (1.786)			
Disp*SurveySenti		-3.011 (1.839)			
Rain			-3.207*** (0.953)		
Disp*Rain			-1.091 (0.887)		
Solar				6.250*** (1.161)	
Disp*Solar				-0.486 (1.097)	
Temp					5.644*** (1.101)
Disp*Temp					0.305 (1.034)
Constant	2.103 (1.588)	1.599 (1.622)	2.495 (1.616)	3.013* (1.605)	2.496 (1.583)
Housing Char.	Yes	Yes	Yes	Yes	Yes
Suburb F.E.	Yes	Yes	Yes	Yes	Yes
Year Quarter F.E.	Yes	Yes	Yes	Yes	Yes
Cluster S.E.	Yes	Yes	Yes	Yes	Yes
N	55,149	55,149	55,149	54,686	55,149
Adj Rsq	0.820	0.820	0.820	0.820	0.820