Auction and Negotiated Housing Price Dynamics

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Introduction

- How properties sell matters for housing price dynamics
- (Using M and S data:) Auction (vs. Negotiated) prices:
  - Forecast better
  - Have less momentum
  - Respond to permanent shocks uniformly faster
  - → sellers sluggish compared to buyers
    - move from *findings* to *statements about buyers and sellers*:

    add in list prices (which are to neg. as neg. are to auctions),
    estimate a state-space model with all three, and
    rely on the mechanisms to apply buyer/seller labels to diffusion processes
- Of interest, since:
  - Housing important to macro
  - Micro interest in functioning of different price mechanisms

Macro-Importance

- Propagation Mechanism
  - Iacovellio (2005): as collateral
  - Kaplan, Violante and Moll (2018): → MPC
- Shock in own right
- Banking System
  - mortgage performance
  - solvency and stability of banking system
- MICRO-HOUSING:
  - dynamics as indicating market frictions or bubbles.

Macro/Finance Lit. on Housing Prices

- Basic Facts:
  - Case and Shiller (1989)
  - Titman, Wang and Yang (2014)
  - Glaeser, Gyourko, Morales and Nathanson (2014): standard asset model "fails utterly at explaining the strong, high frequency positive serial correlation of price changes"
- Search frictions:
  - Capozza, Hendershott and Mack (2004)
  - Caplin and Leahy (2011)
  - Diaz and Jerez (2013): *none*
  - Head, Lloyd-Ellis and Sun (2014): < 0.5 and $zero$
- Adaptive Expectations
  - Sommervoll, Borgeersen and Wennemo (2010)
- Momentum Traders
  - Piazzesi and Schneider
- Kinked Demand Curves
  - Guren (2015)

Micro: Mechanisms in General

- Mechanisms generally evaluated according to:
  - Efficiency
  - Revenue
  - Robustness
  - Simplicity
  - Information Aggregation: Informative (Kremer)
  - Price's Approximation of Asset Value
- Empirical Literature (esp. Internet):
  - Lucking-Reiley (1999)
  - Einav et al (2015)
- No studies on dynamics of how mechanisms translate shocks into prices

Why Australia

- Australia has had a substantial share of real estate auctions for a long time (at least since 1959, [Maher])
- In our data, about 11 percent of sales
- Not foreclosures (as in US)
- Rather, dwellings are sometimes auctioned, sometimes offered via private sale (“negotiated”)

Data

- Sydney and Melbourne:
  - 1993-2016
  - approx. 4 million transactions (census)
  - 40% of Australian transactions, 60% of value
- Land title office records merged with listings data from newspapers and Internet
- Sales Price
- Method of Sale
- Attributes:
  - Physical
  - Geographic

Table 1—Sales Frequency by Selling Mechanism

	Sydney		Melbourne	
	Houses	Apartments	Houses	Apartments
Auction share	10.45	6.23	15.39	9.83
Negotiated share	89.55	93.77	84.61	90.17
Number of observations	1,239,835	709,012	1,2912,314	535,867

Note: Sales frequencey is measured by percent and excludes 'mixed-mechansim' sales where either: a) the property is listed for auction but is sold via negotiation prior to auction; or b) the auction is held but fails to meet the sellers reser

Table 2—Sales Frequency by Property Type

	Sydney		Melbourne	
	Auction	Negotiated	Auction	Negotiated
		Houses		
Cottage	3.04	0.61	0.00	0.00
Detached house	60.39	53.78	73.45	63.98
Semi-detached	2.92	0.51	0.01	0.00
Terrace	3.43	0.44	1.13	0.58
Townhouse	4.57	6.95	4.30	4.73
Villa	0.21	0.26	0.17	0.06
		Apartments		
Duplex	0.71	0.45	0.17	0.15
Studio	0.34	0.26	0.00	0.01
Unit	24.38	36.74	20.76	30.49

Note: Sales frequencey is measured by percent and excludes 'mixed-mechansim' sales where either: a) the property is listed for auction but is sold via negotiation prior to auction; or b) the auction is held but fails to meet the sellers reserve and is subsequently sold via negotiation.

Attributes are not Identically Distributed Across Mechanisms

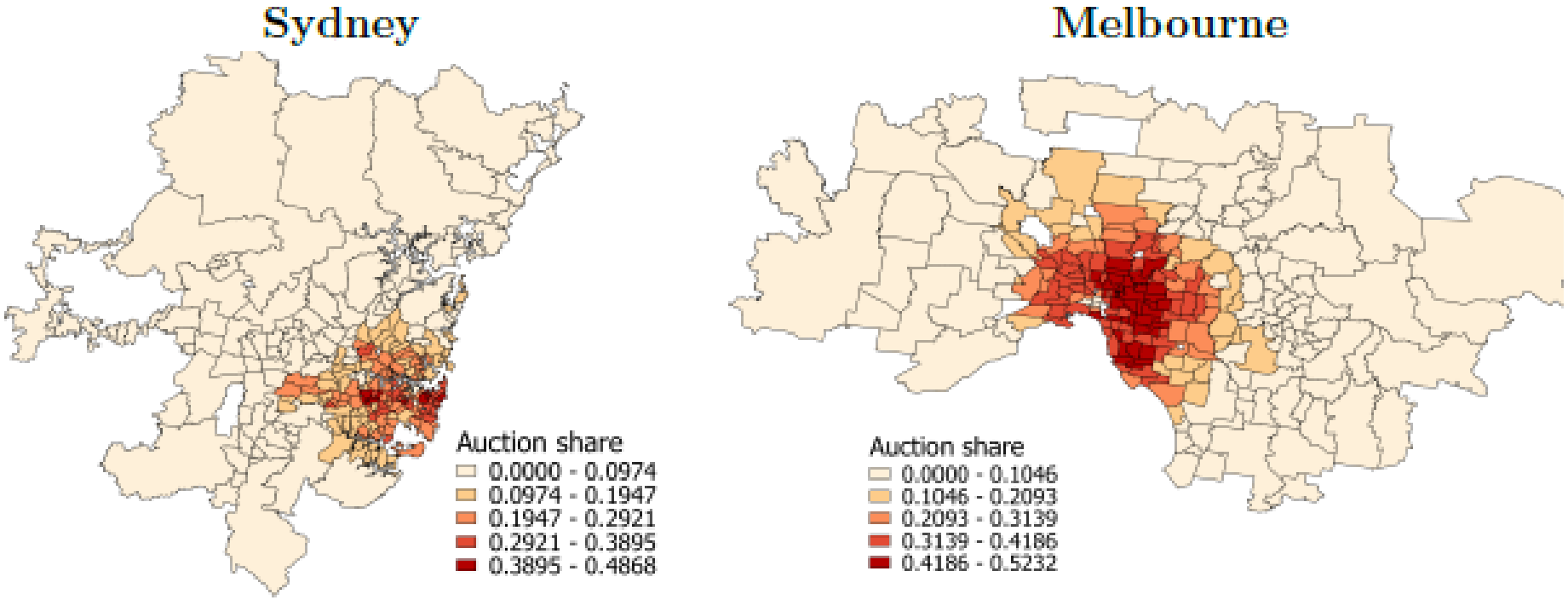
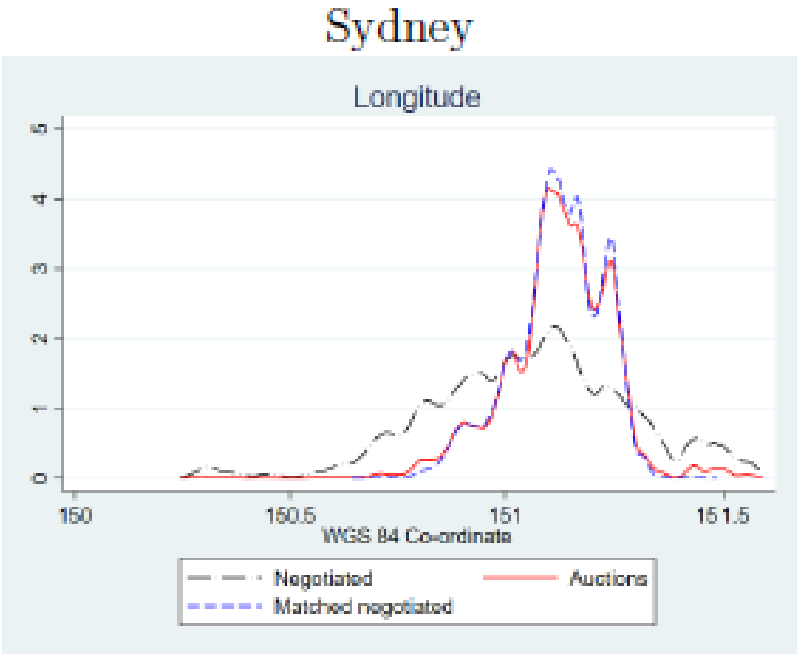
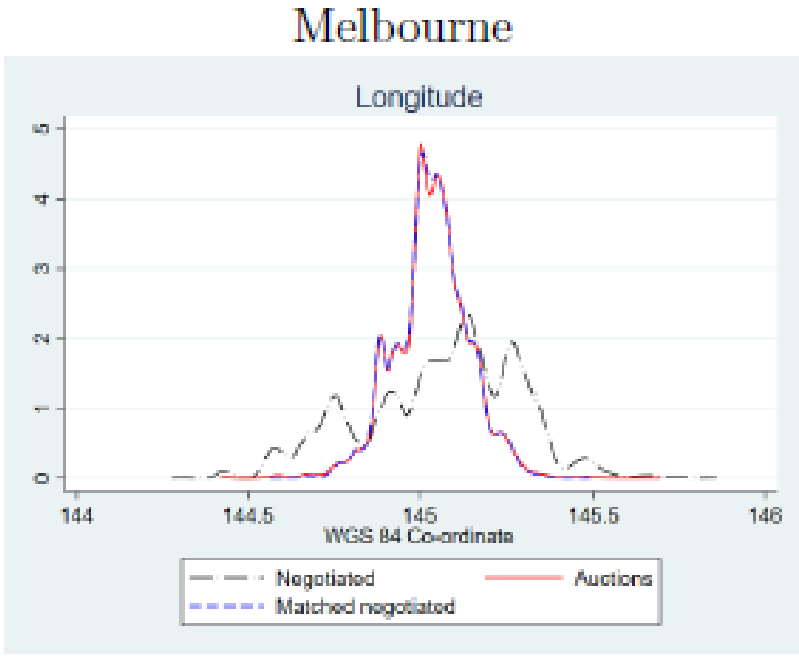
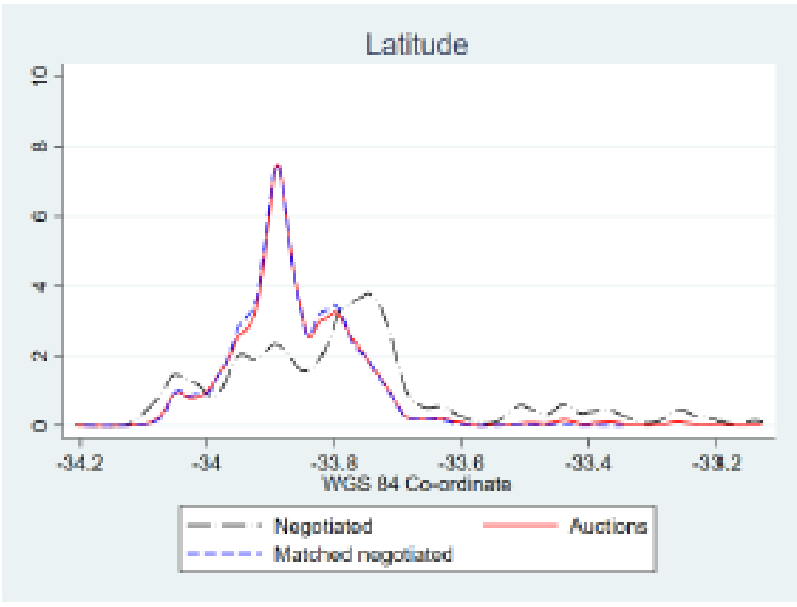


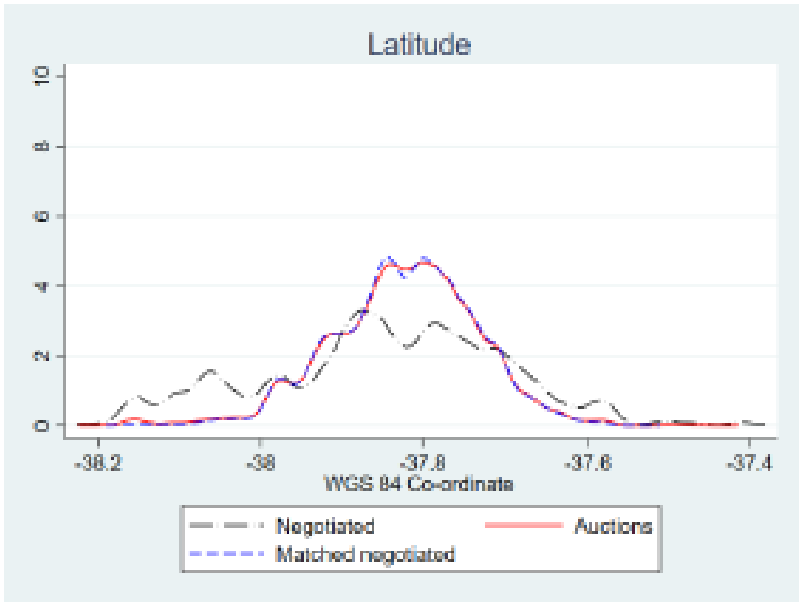
FIGURE 1. AUCTION INCIDENCE BY POSTCODE

Nearest Neighbour Matching (NNM)









Matching – Nearest Neighbour: SYDNEY

TABLE 3—MEAN CHARACTERISTICS OF AUCTIONS AND PRIVATE-TREATIES – SYDNEY HOUSES

	Auctions		Negotiated		Overlap measures			
	$N_a = 83,211$		$N_p = 404,832$		Raw	Nor.	Log ratio	
X	Mean	(S.D.)	Mean	(S.D.)	Δ	Δ	of S.D.	π_X
				Before matching				
Beds	3.37	(0.90)	3.45	(0.84)	-0.07	-0.09	0.14	0.05
Baths	1.77	(0.77)	1.77	(0.75)	-0.01	-0.01	0.07	0.02
Lat.	-33.86	(0.11)	-33.80	(0.19)	-0.07	-0.47	-1.06	0.01
Long.	151.12	(0.13)	151.06	(0.23)	0.07	0.35	-1.19	0.01
Log size	6.29	(0.65)	6.53	(0.66)	-0.24	-0.37	-0.04	0.09
Distance	14.96	(11.68)	28.87	(19.01)	-13.91	-0.88	-0.97	0.09
H index	0.56	(0.46)	0.48	(0.35)	0.08	0.21	0.55	0.09
Turnover	1.13	(0.38)	1.34	(0.57)	-0.20	-0.42	-0.81	N/A
				After matching				
	$N_a = 79,623$		$N_p = 79,623$					
Beds	3.38	(0.90)	3.38	(0.90)	0.00	0.00	0.00	0.00
Baths	1.77	(0.77)	1.77	(0.77)	0.00	0.00	0.00	0.00
Lat.	-33.87	(0.08)	-33.87	(0.08)	0.00	0.00	0.00	0.05
Long.	151.12	(0.10)	151.12	(0.10)	0.00	0.00	0.01	0.05
Log size	6.27	(0.65)	6.27	(0.63)	0.01	0.01	0.06	0.06
Distance	13.38	(8.19)	13.35	(8.25)	-0.03	0.00	0.01	0.06
H index	0.22	(0.16)	0.23	(0.18)	0.01	0.06	0.19	0.08
Turnover	1.14	(0.38)	1.09	(0.31)	0.05	0.14	0.44	N/A

Matching – Nearest Neighbour: MELBOURNE

TABLE 4—MEAN CHARACTERISTICS OF AUCTIONS AND PRIVATE-TREATIES – MELBOURNE HOUSES

	Auctions		Negotiated		Overlap measures			
	$N_a = 112,883$		$N_p = 375,758$		Raw	Nor.	Log ratio	
	Mean	(S.D.)	Mean	(S.D.)	Δ	Δ	of S.D.	π_X
				Before matching				
Beds	3.09	(0.75)	3.31	(0.72)	-0.21	-0.29	0.10	0.09
Baths	1.58	(0.62)	1.70	(0.59)	-0.12	-0.20	0.12	0.13
Lat.	-37.82	(0.09)	-37.85	(0.15)	0.03	0.21	-0.95	0.00
Long.	145.04	(0.11)	145.06	(0.22)	-0.02	-0.12	-1.44	0.00
Log size	6.19	(0.58)	6.36	(0.62)	-0.18	-0.30	-0.13	0.05
Distance	13.43	(7.44)	24.19	(12.32)	-10.75	-1.06	-1.00	0.09
H index	0.24	(0.14)	0.20	(0.11)	0.03	0.26	0.46	0.13
Turnover	1.13	(0.36)	1.31	(0.55)	-0.18	-0.39	-0.84	N/A
				After matching				
	$N_a = 110,763$		$N_p = 110,763$					
Beds	3.09	(0.75)	3.09	(0.75)	0.00	0.00	0.01	0.00
Baths	1.58	(0.63)	1.58	(0.63)	0.00	0.00	0.00	0.00
Lat.	-37.82	(0.09)	-37.82	(0.09)	0.00	0.00	0.00	0.05
Long.	145.04	(0.10)	145.04	(0.10)	0.00	0.00	-0.01	0.05
Log size	6.18	(0.58)	6.18	(0.57)	0.00	0.01	0.04	0.06
Distance	13.07	(6.74)	13.01	(6.74)	-0.05	-0.01	0.00	0.05
H index	0.23	(0.13)	0.23	(0.14)	0.00	0.01	0.13	0.09
Turnover	1.13	(0.37)	1.09	(0.30)	0.04	0.13	0.37	N/A

Note: See note under Table 3.

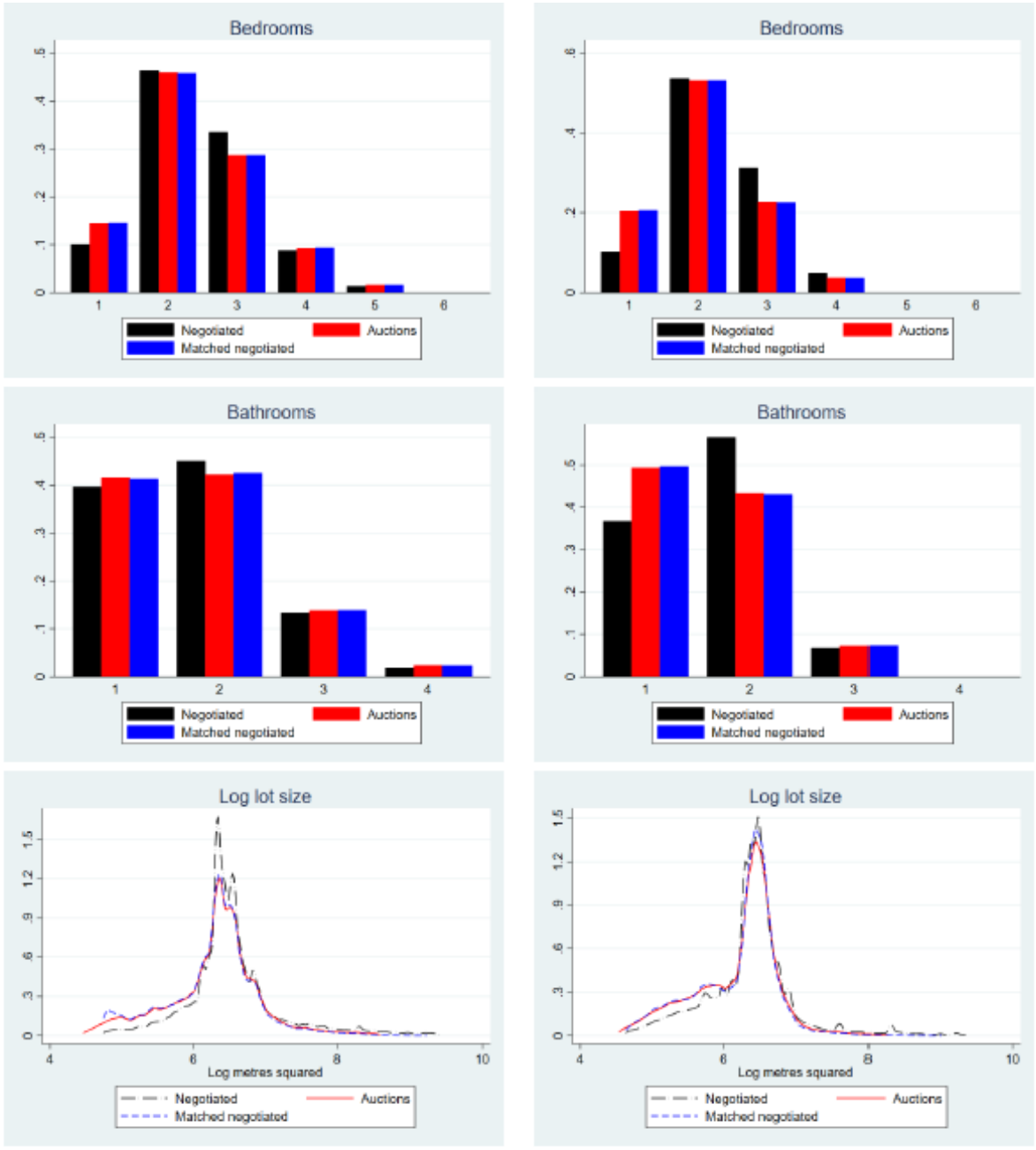


FIGURE 2. COVARIATE BALANCE – HOUSES

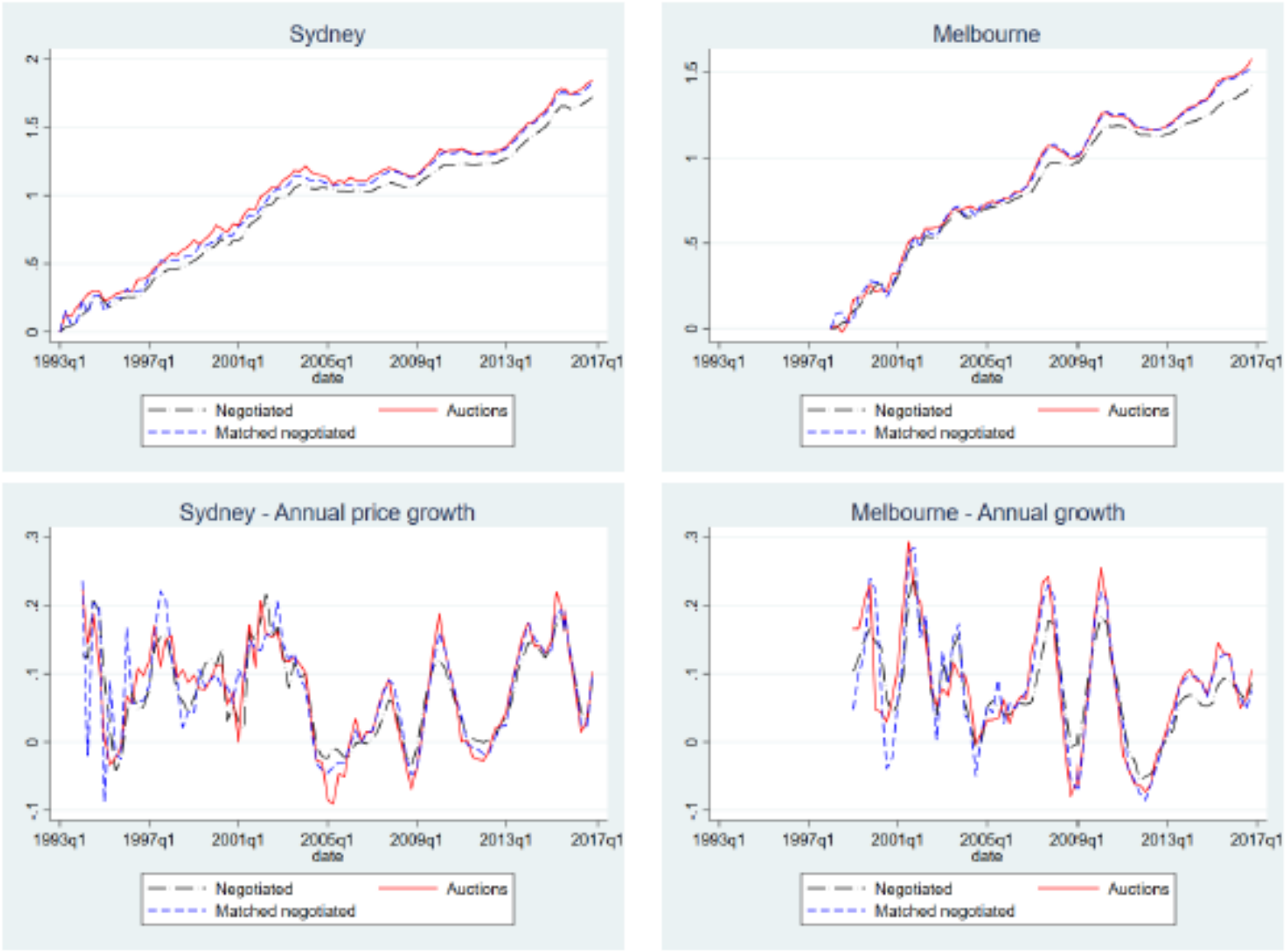


FIGURE 3. ESTIMATED LOG PRICE INDICES

Propensity Score Balancing

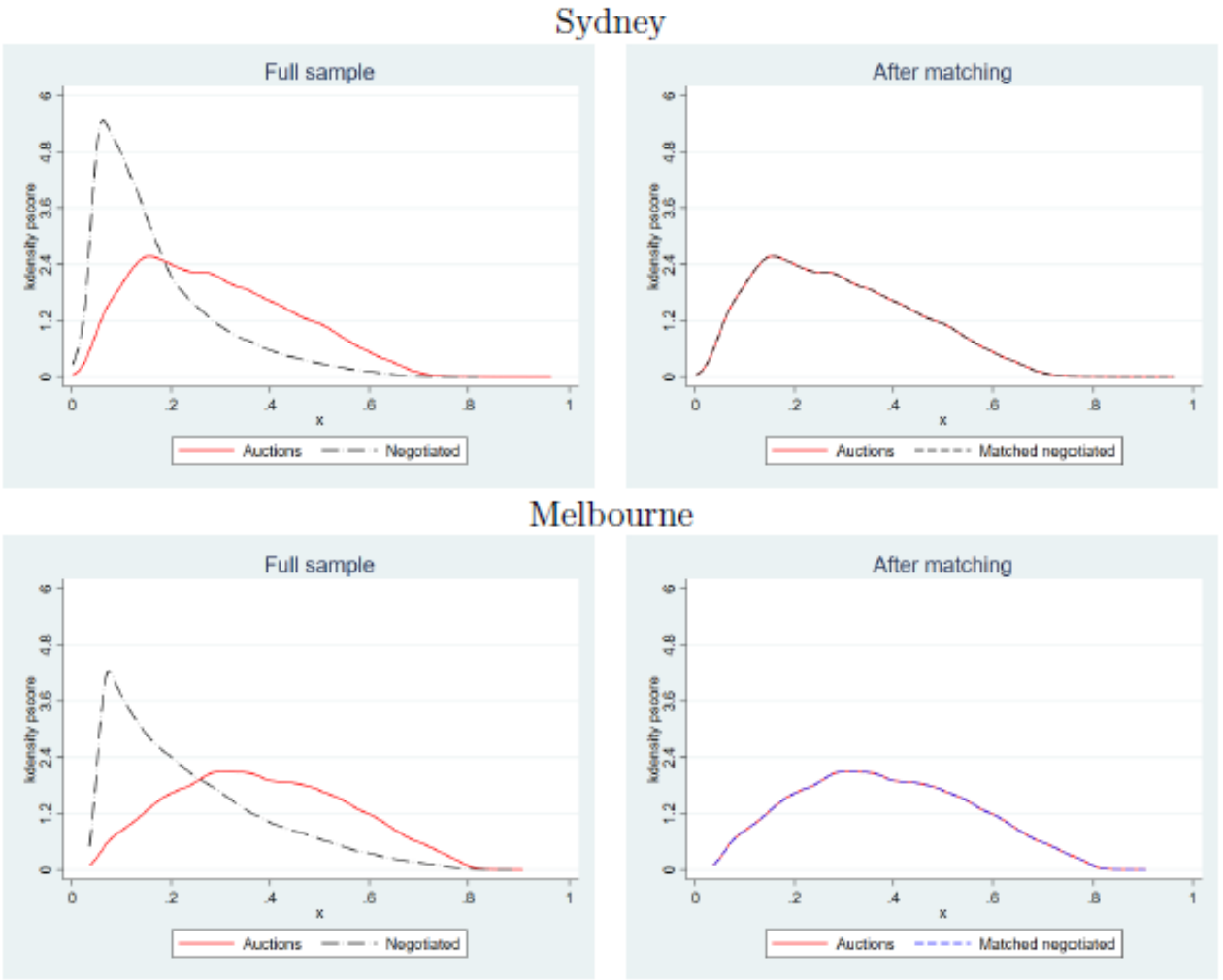


FIGURE A5. ESTIMATED PROPENSITY SCORE DISTRIBUTIONS

Note: Kernal density graphs for the estimated propensity score for auction using a logistic model that includes all home attributes and geodetic distance to the city centre.

MOMENTUM:

- **RANDOM WALK TESTS**
- **AUTOCORRELATION**
- **DIFFUSION OF A PERMANENT SHOCK**

Random Walk (with Drift) Tests

TABLE A5—TESTS FOR A RANDOM WALK WITH DRIFT

	Sydney		**Melbourne**	
Null hypothesis[(c)]	Nearest Neighbour	Propensity Score	Nearest Neighbour	Propensity Score
$E\left(a_{t+1}\middle\vert\mathcal{I}_t^a\right)=c^a+a_t$	0.95	1.01	1.51	1.51
	(0.44)	(0.41)	(0.19)	(0.19)
$E\left(p_{t+1}\middle\vert\mathcal{I}_t^{a,p}\right)=c^p+p_t$	35.20^{***}	40.62^{***}	35.95^{***}	61.40^{***}
	(0.00)	(0.00)	(0.00)	(0.00)

Note: [(a)] The null hypothesis is of no autocorrelation in prices growth where $\mathcal{I}_t^a$ denotes the information set conditioning on lagged auction prices, and $\mathcal{I}_t^{a,p}$ denotes the information set conditioning on both lagged auction and negotiated prices.

Autocorrelations

TABLE 5—MOMENTUM IN PRICES GROWTH

	Price Growth Autocorrelations			
	$t-1$	$t-2$	$t-3$	$t-4$
		Sydney		
All sales	0.46***	0.21**	0.13	0.08
Auctions	0.08	0.20*	0.06	0.10
Negotiatied	0.40**	0.15**	0.02	0.08
Matched negotiated	0.33***	0.21*	0.08	0.18
		Melbourne		
All sales	0.45***	0.15	-0.03	-0.21
Auctions	0.21*	0.11	-0.02	-0.08
Negotiated	0.36***	0.15	-0.04	-0.23
Matched negotiated	0.24**	0.12	-0.10	-0.04

Note: [a] The price measures are estimated using the hedonic index with all attributes. Matched negotiated are based on the negotiated sales sample after nearest neighbor matching. [b] In this and all subsequent tables ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.

Momentum – Repeat Sales

TABLE A9—MOMENTUM IN REPEAT-SALES PRICES GROWTH

	Price Growth Autocorrelations			
	$t-1$	$t-2$	$t-3$	$t-4$
		Sydney		
All sales	0.67***	0.44***	0.27*	0.26
Auctions	0.11	0.21*	-0.13	0.17
Negotiated	0.71***	0.49***	0.33**	0.28
		Melbourne		
All sales	0.60***	0.38***	0.17*	0.10
Auctions	0.16	0.11	0.01	-0.06
Negotiated	0.65***	0.44***	0.28**	0.16

Note: [a] The price measures are estimated using the weighted repeat-sales indices (Case and Shiller, 1989) over the full sample. [b] In this and all subsequent tables ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.

Permanent Shock Diffusion

FIGURE 5. DIFFUSION OF PERMANENT COMMON SHOCKS

Note: Point estimates denote the cumulative pass-through of a permanent shock with 90 per cent confidence bands. Estimates are obtained from a structural VECM in auction and negotiated prices.

PREDICTION:

GRANGER CAUSALITY

Granger Causality and Information Content

TABLE 6—CAUSALITY AND INFORMATION CONTENT

	Sydney			Melbourne		
	NM	NNM	PSM	NM	NNM	PSM
Granger causality						
$H_0 : E[p_{t+1} \mid \mathcal{J}_t]$	44.12^{***}	28.57^{***}	39.09^{***}	23.71^{***}	30.89^{***}	54.39^{***}
$= E[p_{t+1} \mid \mathcal{J}_t^p]$	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$H_0 : E[a_{t+1} \mid \mathcal{J}_t]$	1.23	8.56	4.25	4.16	7.38	5.46
$= E[a_{t+1} \mid \mathcal{J}_t^a]$	(0.94)	(0.13)	(0.51)	(0.38)	(0.12)	(0.24)
Directed information						
$F_{a_t \to p_t}$	0.21	0.17	0.15	0.14	0.20	0.33
$F_{p_t \to a_t}$	-0.03	0.03	-0.01	0.00	0.03	-0.02

Note: [a] $\mathcal{J}_t$ denotes information set: a_{t-j}, p_{t-j} for $j \geq 0$ and $\mathcal{J}_t^a : a_{t-j}$ for $j \geq 0$, and $\mathcal{J}_t^p : p_{t=j}$ for $j \geq 0$. [b] NM denotes that the causality tests are undertaken with respect to the original (unmatched) measures of auction and negotiated prices, NNM on the matched samples after nearest neighbor matching, and PSM after matching on the estimated propensity score. [c] $F_{p_t \to a_t} \equiv ln\left(\Sigma_1^{a_t}/\Sigma_2^{a_t}\right)$ $(F_{a_t \to p_t} \equiv ln\left(\Sigma_1^{p_t}/\Sigma_2^{p_t}\right))$ denotes Geweke's measure of past linear dependence and can be interpreted as a measure of directed information (Amblard and Michel, 2013). $\Sigma_1^{a_t}$ $(\Sigma_1^{a_t})$ and $\Sigma_2^{a_t}$ $(\Sigma_2^{p_t})$ denote the asymptotic variances of the restricted and unrestriced models for auction (negotiated) prices.

Granger Causality: Repeat Sales

TABLE A10—CAUSALITY TESTS WITH REPEAT-SALES

	Sydney		Melbourne	
Null hypothesis[(a)]	NM	NNM	NM	NNM
$H_0 : E\left[p^r_{t+1} \mid \mathcal{J}_t^{a^r,p^r}\right]$	6.94	9.04	1.65	4.65
$= E\left[p^r_{t+1} \mid \mathcal{J}_t^{p^r}\right]$	(0.23)	(0.11)	(0.80)	(0.32)
$H_0 : E\left[a^r_{t+1} \mid \mathcal{J}_t^{a^r,p^r}\right]$	9.25*	23.55***	27.76***	78.83***
$= E\left[a^r_{t+1} \mid \mathcal{J}_t^{a^r}\right]$	(0.09)	(0.00)	(0.00)	(0.00)

Note: a^r_t denotes repeat-auction prices and p^r_t denotes repeat-negotiated prices. NM denotes the unmatched weighted-repeat sales index (Case and Shiller, 1989) and NNM denotes a matched repeat-sales index where a matched sample of nearest neighbor negotiations are identified by matching on the date of the first sale, the date of resale, home type (exactly), longitude, latitude and log size.

Granger Causality for Macro-Variables

TABLE 7—CAUSALITY TESTS WITH CONTROLS FOR MACROECONOMIC CONDITIONS

	Sydney VARs			Melbourne VARs		
Null[(a)]	a_t, p_t v_t, r_t	a_t, p_t y_t, r_t	a_t, p_t y_t, r_t, π_t	a_t, p_t v_t, r_t	a_t, p_t y_t, r_t	a_t, p_t y_t, r_t, π_t
$p_t \overset{gc}{\nrightarrow} a_t$	1.23	3.32	3.88	1.75	3.79	6.69
$p_t \overset{gc}{\nrightarrow} v_t$	6.05			4.51		
$p_t \overset{gc}{\nrightarrow} r_t$	2.62	5.08	3.14	3.20	4.96	5.93
$p_t \overset{gc}{\nrightarrow} y_t$		2.56	2.09		4.94	4.96
$p_t \overset{gc}{\nrightarrow} \pi_t$			3.00			4.72
$a_t \overset{gc}{\nrightarrow} p_t$	55.37***	79.06***	59.56***	31.03***	64.14***	52.14***
$a_t \overset{gc}{\nrightarrow} v_t$	10.90**			8.63*		
$a_t \overset{gc}{\nrightarrow} r_t$	9.12**	12.61***	7.52*	1.26	3.47	1.93
$a_t \overset{gc}{\nrightarrow} y_t$		7.62*	6.20		9.65**	16.21***
$a_t \overset{gc}{\nrightarrow} \pi_t$			6.38*			2.91

Note: [(a)] $x_t \overset{gc}{\nrightarrow} z_t$ denotes a test of the null hypothesis that x_t does not Granger cause z_t. a_t denotes auction prices, p_t negotiated prices, v_t the nominal value of building approvals, r_t the city-specific ex post real interest rate, y_t real state final demand and π_t state inflation. The macroeconomic data are outlined in Appendix A.A8.

ROBUSTNESS

Granger Causality: "Pre-Auction" Prices

TABLE 9—CAUSALITY AND DIRECTED INFORMATION WITH PRE-AUCTION PRICES

	Sydney		Melbourne	
	All attributes	Limited attributes	All attributes	Limited attributes
Granger causality				
$H_0 : E[p_{t+1} \mid \mathcal{J}_t] = E[p_{t+1} \mid \mathcal{J}_t^p]$	3.34	2.59	3.47	4.49
$H_0 : E[s_{t+1} \mid \mathcal{J}_t] = E[s_{t+1} \mid \mathcal{J}_t^s]$	41.49***	34.09***	35.65***	34.34***
Information				
$F_{s_t \to p_t}$	0.00	-0.01	0.00	0.00
$F_{p_t \to s_t}$	0.16	0.16	0.24	0.17

Note: [a] $\mathcal{J}_t$ denotes information set: a_{t-j}, s_{t-j} for $j \geq 0$ and $\mathcal{J}_t^p : p_{t-j}$ for $j \geq 0$, and $\mathcal{J}_t^s : s_{t=j}$ for $j \geq 0$ and so the null hypothesis in the first row is that pre-auction prices (s_t) do not Granger cause negotiated prices (p_t) while that in the third row is that negotiated prices do not Granger cause pre-auction prices. [b] All attributes includes controls for lot size, postcode, property type, bedrooms and bathrooms and limited attributes includes controls for lot size, postcode, and property type only.

Selection Correction

TABLE 8—GRANGER CAUSALITY WITH ADJUSTMENTS FOR ENDOGENOUS SELECTION

Null hypothesis	Sydney			Melbourne		
	No adjust.	In price	In price & VAR	No adjust.	In price	In price & VAR
$H_0 : E[\widetilde{p}_{t+1} \mid \mathcal{J}_t]$	40.91***	46.61***	35.12***	13.81***	17.55***	19.00***
$= E\left[\widetilde{p}_{t+1} \mid \mathcal{J}_t^{\widetilde{p}}\right]$	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$H_0 : E[\widetilde{a}_{t+1} \mid \mathcal{J}_t]$	3.52	3.84	3.67	4.24	3.60	2.32
$= E\left[\widetilde{a}_{t+1} \mid \mathcal{J}_t^{\widetilde{a}}\right]$	(0.17)	(0.15)	(0.16)	(0.24)	(0.31)	(0.51)

Note: Tilde super scripts are used to denote the prices estimated on the repeat-sales sample, with and without adjustments for time-varying seller selection. No adjust. uses a VAR with the standard hedonic index (i.e. no adjustment for seller selection). In price results use a VAR with the selection-adjusted price indices as estimated in (A7) to (A9) in the online Appendix (i.e. adjusting for selection when measuring prices but not within the information set used to test for causality). In VAR uses a VAR with the selection-adjusted price indices and the time dummy coefficients in (A7) (i.e. adjusts for selection when measuring prices and includes it in the information set when testing for causality).

No single district is driving the result

TABLE 11—CAUSALITY TESTS WITHIN DISTRICTS

District[a]	$H_0 : a_t \overset{gc}{\nrightarrow} p_t$	$H_0 : p_t \overset{gc}{\nrightarrow} a_t$	Auction share
		Sydney[b]	
Central Coast	9.97***	1.51	0.04
Baulkham Hills	9.01***	1.32	0.06
Blacktown	7.81***	1.02	0.06
City and Inner South	13.35***	2.07	0.24
Eastern Suburbs	36.41***	2.59	0.35
Inner South West	9.34***	1.81	0.20
Inner West	6.05***	1.81	0.30
North Sydney	4.53**	1.30	0.17
Northern Beaches	29.77***	0.61	0.11
Outer South West	4.18***	0.78	0.03
Outer West	2.53*	1.72	0.02
Parramatta	5.21**	1.96	0.13
Ryde	5.51***	1.92	0.22
South West	3.39**	2.39	0.13
Sutherland	16.79***	0.20	0.14
		Melbourne[c]	
Inner	2.03**	1.34	0.18
Inner East	12.66***	1.81	0.26
Inner South	6.12***	1.31	0.23
North East	4.82***	1.03	0.15
North West	2.88**	1.50	0.12
Outer East	2.53**	1.63	0.06
South East	2.49**	1.76	0.06
West	2.94***	2.06*	0.09
Sydney – all districts	46.17***	1.78	0.16
Melbourne – all districts	13.48***	2.53*	0.14

Note: [a] The within-district causality tests are F-test statistics for non-Granger causality(Toda and Yamamoto, 1995). For the null hypothesis is that auction prices do not Granger cause negotiated prices in any district against the alternative of causality in at least one district the $\bar{Z}_N^{H^{nc}}$ test statistic is used with bootstrapped critical values (Dumitrescu and Hurlin, 2012). [b] For Sydney all controls (postcode, property type, bedrooms, bathrooms and log lot size) are included when measuring price. For Melbourne, only limited controls (postcode, property type and log lot size) are used to maximize the sample size for each district and over time.

Other Sub-Samples

TABLE 12—ADDITIONAL CAUSALITY TESTS

	Sydney		Melbourne	
	$H_0 : a_t \overset{gc}{\nrightarrow} p_t$	$H_0 : p_t \overset{gc}{\nrightarrow} a_t$	$H_0 : a_t \overset{gc}{\nrightarrow} p_t$	$H_0 : p_t \overset{gc}{\nrightarrow} a_t$
Detached homes only[(a)]	19.19***	0.53	9.17***	1.09
Limited attributes[(b)]	18.32***	8.93	40.34***	4.20
Detailed attributes[(c)]	20.86***	0.04	3.96***	1.72
Above avg. idiosyncracy[(d)]	7.09***	2.00*	8.05***	1.03
Below avg. idiosyncracy[(e)]	30.01***	0.36	9.52***	0.57
Matched repeat-sales[(f)]	23.55***	9.04	78.83***	4.65

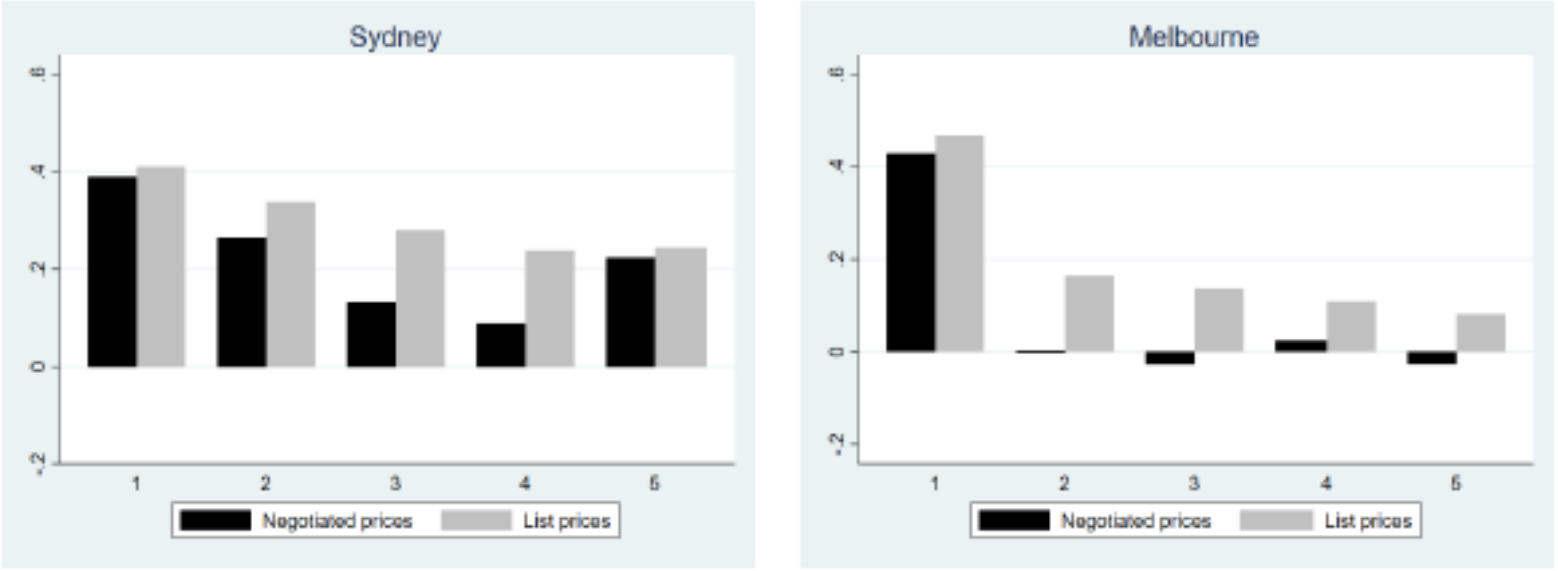
Note: [(a)] Detached homes only excludes all unit and apartment sales. [(b)] Limited attributes includes controls from property type, postcode and log land size only. [(c)] Detailed attributes controls for property type, postcode, bedrooms, bathrooms, log size and a vector of 34 detailed attributes (see Appendix A.A9). [(d)] Above avg. idiosyncrasy denotes the sample of sales weakly above the estimated mean Haurin index (Haurin, 1988). [(e)] Below avg. idiosyncrasy denotes the sample of sales strictly below the estimated mean Haurin index. [(f)] Denotes a matched repeat-sales index where a matched sample of nearest neighbor negotiations are identified by matching on the date of the first sale, the date of resale, home type (exactly), longitude, latitude and log size.

To Make Inferences About Buyers and Sellers, we need:

LIST PRICES

Momentum: List vs. Negotiated

FIGURE 6. MOMENTUM IN LIST AND NEGOTIATED PRICES



Note: The above figure reports the autocorrelation coefficents for list and negotiated prices restricted to the common sub-sample where both the list price and final transaction price are observed.

Granger Causality with List Prices

TABLE 10—GRANGER CAUSALITY AND DIRECTED INFORMATION WITH LIST PRICES

	Sydney		Melbourne	
	NM	NNM	NM	NNM
List and negotiated prices				
$H_0 : E\left[l_{t+1} \mid \mathcal{J}_t^{l,p}\right] = E\left[l_{t+1} \mid \mathcal{J}_t^{l}\right]$	41.85***	48.54***	54.67***	19.80***
$H_0 : E\left[p_{t+1} \mid \mathcal{J}_t^{l,p}\right] = E\left[p_{t+1} \mid \mathcal{J}_t^{p}\right]$	11.65**	13.04**	17.12***	23.24***
List and auction prices				
$H_0 : E\left[l_{t+1} \mid \mathcal{J}_t^{l,a}\right] = E\left[l_{t+1} \mid \mathcal{J}_t^{l}\right]$	52.71***	61.74***	59.13***	41.27***
$H_0 : E\left[a_{t+1} \mid \mathcal{J}_t^{l,a}\right] = E\left[a_{t+1} \mid \mathcal{J}_t^{a}\right]$	3.06	4.99	4.96	5.26
Information				
$F_{p_t \to l_t}$	0.29	0.32	0.37	0.13
$F_{l_t \to p_t}$	0.07	0.08	0.09	0.16
$F_{a_t \to l_t}$	0.36	0.38	0.37	0.27
$F_{l_t \to a_t}$	0.02	0.00	0.00	0.01

Note: [a] $\mathcal{J}_t^{x,y}$ denotes information set: x_{t-j}, y_{t-j} for $j \geq 0$ and $\mathcal{J}_t^{x} : x_{t-j}$ for $j \geq 0$. Auction, list and negotiated prices are denoted by a_t, l_t and p_t respectively. [b] NM denotes results using the original (unmatched) samples and with only limited attribute controls (property type, log lot size and postcode). NNM denotes results using the matched samples after nearest neighbour matching and with all attribute controls.

STATE SPACE MODEL

Preliminary: Co-Integration

TABLE A6—COINTEGRATION ANALYSIS

	Sydney		Melbourne	
Maximum rank[a]	Trace statistic	5% Critical value	Trace statistic	5% Critical value
0	66.72**	42.44	51.09**	42.44
1	32.54**	25.32	25.50**	25.32
2	5.56	12.25	5.77	12.25
Cointegration vectors[b]	β_1	β_2	β_1	β_2
a_t	1.00	0.00	1.00	0.00
	(.)	(.)	(.)	(.)
l_t	0.00	1.00	0.00	1.00
	(.)	(.)	(.)	(.)
p_t	-1.05	-1.00	-1.00	-1.02
	(0.06)	(0.04)	(0.08)	(0.07)
c	0.04	-0.09	-0.05	-0.05
	(.)	(.)	(.)	(.)
t	0.003	0.001	-0.0002	0.003
	(0.0008)	(0.0007)	(0.0002)	(0.001)

Note: [a] ** denotes rejection of the null of the maximal rank being achieved using sequential application of the Johansen trace test with the type-I error held fixed at 5 percent. Standard errors are in parentheses. [b] The cointegrating vectors have been normalized and standard errors are reported as (.) for normalized coefficients. All tests allow for a constant and a linear trend in the cointegrating relationship.

State-Space Model

$$\text{(A1)} \qquad \Delta a_t = \mu_a + g^{-1}\left(\gamma_1^a\right)\Delta v_{1,t} + \left[1 - g^{-1}\left(\gamma_1^a\right)\right]\Delta v_{2,t} + \varepsilon_t^a - \varepsilon_{t-1}^a$$

$$\text{(A2)} \qquad \Delta p_t = g^{-1}\left(\gamma_1^p\right)\Delta v_{1,t} + \left[1 - g^{-1}\left(\gamma_1^p\right)\right]\Delta v_{2,t} + \varepsilon_t^p - \varepsilon_{t-1}^p$$

$$\text{(A3)} \qquad \Delta l_t = \mu_l + g^{-1}(\gamma_1^l)\Delta v_{1,t} + [1 - g^{-1}(\gamma_1^l)]\Delta v_{2,t} + \varepsilon_t^l - \varepsilon_{t-1}^l$$

and where the unobsvered states allow for slow diffusion of common shocks t
values:

$$\text{(A4)} \qquad \Delta v_{1,t} = \alpha_1 \Delta v_{1,t-1} + (1 - \alpha_1)\,\Delta z_t$$

$$\text{(A5)} \qquad \Delta v_{2,t} = \alpha_2 \Delta v_{2,t-1} + (1 - \alpha_2)\,\Delta z_t$$

$$\text{(A6)} \qquad \Delta z_t = \mu_z + \eta_t$$

State-Space Model: Theoretical Interpretation

- **Auction Price**:

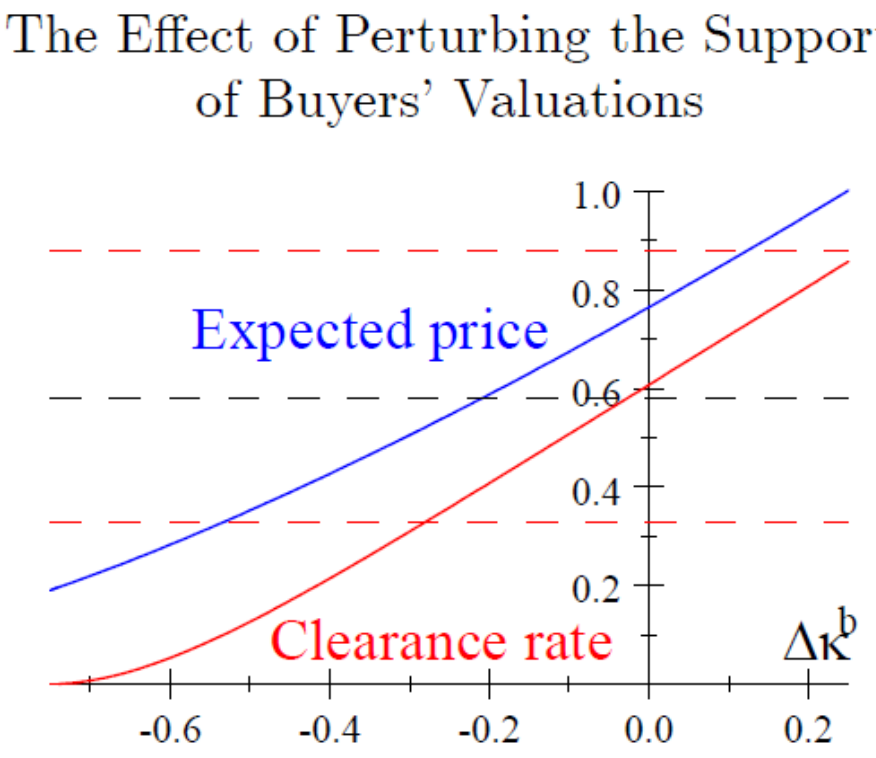
  No reserve: only buyer values

  With reserve, empiric. relevant clearance rates: mostly
- **Negotiated Price**:

  Nash-Bargaining (and other models) -

  price = weighted average of buyer and seller values
- **List Price**: set by sellers

- Values are "dynamic" (Satterthwaite and Shneyerov, 2006): agents' values in the search process.
  - Frictionless world: market prices;
  - With frictions: market conditions plus values post-transaction / information sets.
  - Move together in long run, but deviate from each other in short.



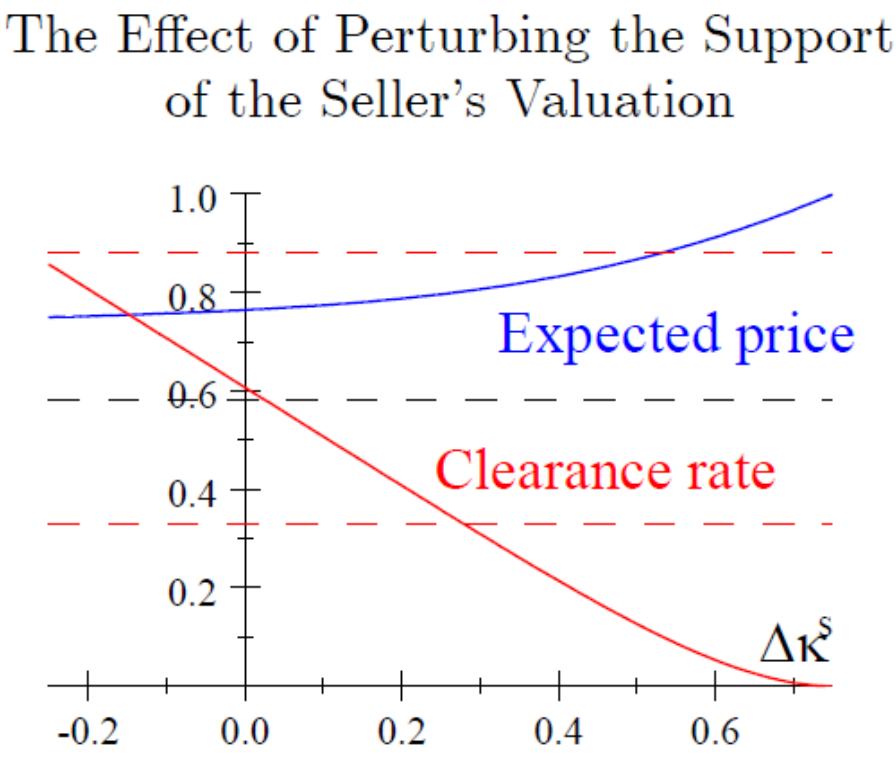


FIGURE 5. ASYMMETRY IN THE RESPONSE OF PRICE

TABLE A7—SYDNEY: 1998:I TO 2016:IV

	Model				
	(1)	(2)	(3)	(4)	(5)
$g^{-1}(\gamma_1^a)$	0.21	0.19	0.00	0.00	0.00
	(0.54)	(0.55)	(.)	(.)	(.)
$g^{-1}(\gamma_1^p)$	0.52	0.52	0.40	0.40	0.50
	(0.32)	(0.33)	(0.08)	(0.08)	(.)
$g^{-1}(\gamma_1^l)$	1.00	1.00	1.00	1.00	1.00
	(0.01)	(.)	(0.00)	(.)	(.)
α_1	0.85	0.85	0.83	0.83	0.83
	(0.07)	(0.07)	(0.02)	(0.02)	(0.02)
α_2	0.43	0.43	0.46	0.46	0.47
	(0.15)	(0.15)	(0.12)	(0.12)	(0.12)
μ_a	-0.002	-0.002	-0.002	-0.002	-0.002
	(0.0002)	(0.0002)	(0.002)	(0.0002)	(0.0002)
μ_l	-0.0024	-0.0014	-0.0014	-0.001	-0.001
	(0.0002)	(0.0002)	(0.002)	(0.0002)	(0.0002)
μ	0.02	0.02	0.02	0.02	0.02
	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
σ_a	0.03	0.03	0.03	0.03	0.03
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
σ_p	0.02	0.02	0.02	0.02	0.02

TABLE A8—MELBOURNE: 2001:I TO 2016:IV

	Model				
	(1)	(2)	(3)	(4)	(5)
$g^{-1}(\gamma_1^a)$	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(.)	(.)	(.)
$g^{-1}(\gamma_1^p)$	0.40	0.40	0.40	0.40	0.50
	(0.09)	(0.09)	(0.09)	(0.09)	(.)
$g^{-1}(\gamma_1^l)$	1.00	1.00	1.00	1.00	1.00
	(0.00)	(.)	(0.00)	(.)	(.)
α_1	0.81	0.81	0.81	0.81	0.81
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
α_2	0.49	0.49	0.49	0.49	0.51
	(0.13)	(0.13)	(0.13)	(0.13)	(0.12)
μ	0.02	0.02	0.02	0.02	0.02
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
μ_a	-0.0003	-0.0003	-0.003	-0.0003	-0.0002
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
μ_l	-0.002	-0.002	-0.002	-0.002	-0.002
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0003)
σ_a	0.01	0.01	0.01	0.01	0.01
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)
σ_p	0.02	0.02	0.02	0.02	0.03

Slow Seller Adjustment

PREVIOUS FINDINGS:

- Sales more cyclical than prices (Leamer, 2007)
- Seller TOM ↓ in hot markets (Genesove & Han, 2012)
- P/L correlated with short run demand growth (Genesove & Han, 2012)
- P/L correlated with price growth (Haurin et al 2013)

NEW EVIDENCE:

- Price growth and auction sales rate: Phillips-curve

Sales Rate and Price Growth

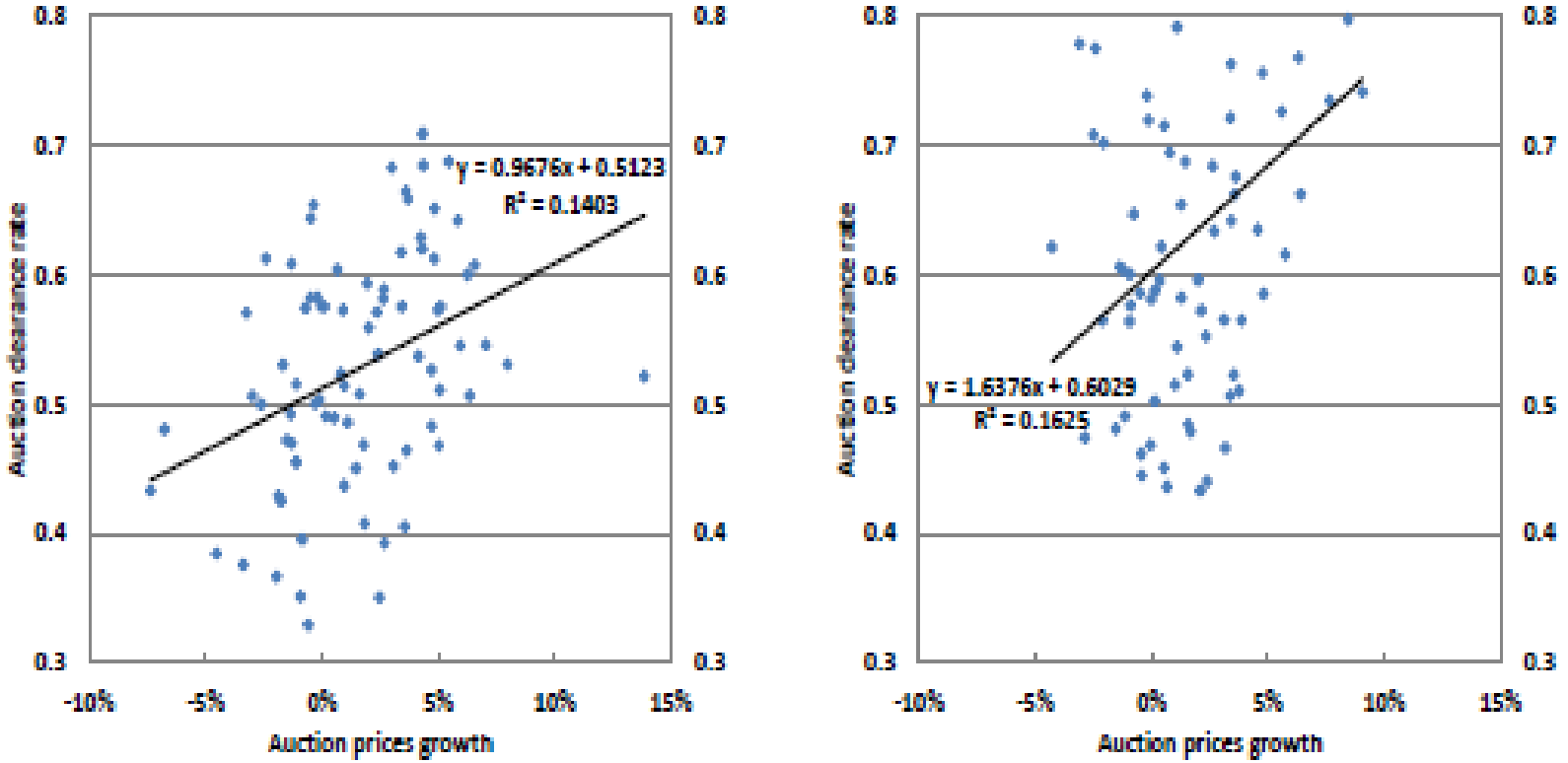


FIGURE 6. SCATTER PLOT OF AUCTION PRICES GROWTH AGAINST AUCTION SALES RATE

Why do Sellers Lag? - I

- WHY LAGS?
  - Quan and Quigley, 1991 (appraisal relies on past)
  - Wheaton, 1990 (JPE; frequency of transaction)
  - Backward looking expectations (Case and Shiller, 1988 - surveys)
- WHY SELLERS LAG?
  - Equity Lock-In (Stein, Genesove and Mayer)
  - Loss Aversion (Genesove and Mayer)
  - Delayed information (Berkovec and Goodman, Genesove and Han)
  - Kinked demand (Guren 2014) – upward only

Why do sellers lag? - II

Some further suggestions …

- Matching institution:
  - Sellers list
  - Buyers do not
  - So buyer information does not diffuse as much
- Buyer has high dimensionality problem → constant adjustment
- (Young) Buyers moving into area, (old) sellers leaving
- Guren (2015): with strategic complementarity, these differences need not be large

Other Explanations

1. Individual auction better estimates underlying common-value component in buyer valuation
   a. However, indices are averages
2. Diffusion of common buyer shocks through the buyer distribution
3. Greater publicity for auctions

Alternative Hypothesis 1: Auctions more precise

- Long standard theoretical literature: COMMON VALUES

- Literature focuses on consistency / unbiasedness of price as estimate of value; but issue is variance of estimator.

	RMSE	
	S	M
Auction	0.27	0.34
Negot.	0.24	0.36

- Aggregation

- Argument is more general

Alternative Explanation 2: Buyer Diffusion

- Auctions depend on second order statistic, negotiated on mean.
- Possible mechanism: shocks diffuse among buyers
- E.g.: (i) no reserve price at auction; (ii) seller has complete bargaining power in negotiations
- Positive shocks will be felt in auctions first:
- Negative shocks felt in negotiated prices first
- Implies asymmetric response, which we do not see in Sydney; opposite direction in Melbourne

Alternative Explanation 3: Publicity

- Auction results are publicized more and earlier
  - More dramatic
  - Attended by more people
  - Concurrently published in newspaper and websites; negotiated published only after a quarter or so
- Buyers and sellers form valuations using past prices
  - Revealing of current market state
  - Assessed values (Quan and Quigley 1991)
  - Expectations backward looking (Case and Shiller 1998, Coibion and Gorodnichenko 2015)
- BUT if negotiated prices are anchored by past auction prices they will inherit auction price (lack of) momentum

Conclusion

- Why is there high momentum in housing prices?
- Answer: sluggish sellers.
- Evidence:
  - auction prices demonstrate less momentum.
  - list prices demonstrate more
  - add price formation ‘theories’
  - (plus some existing and new supporting evidence)
- Calibration studies have assumed sluggish sellers
- Underlying reason remains elusive