Massachusetts Institute of Technology
Department of Economics
Working Paper Series

The Co-Movement of Housing Sales and Housing Prices: Empirics and Theory

William C. Wheaton
Nai Jia Lee

Working Paper 09-05
March 1, 2009

Room E52-251
50 Memorial Drive
Cambridge, MA 02142

4th Draft: March 1, 2009.

The co-movement of Housing Sales and Housing Prices: Empirics and Theory

By

William C. Wheaton
Department of Economics
Center for Real Estate
MIT
Cambridge, Mass 02139
wheaton@mit.edu

and

Nai Jia Lee
Department of Urban Studies and Planning
Center for Real Estate
MIT

The authors are indebted to, the MIT Center for Real Estate, the National Association of Realtors and to Torto Wheaton Research. They remain responsible for all results and conclusions derived there from.

JEL Code: R2. Keyword: Housing

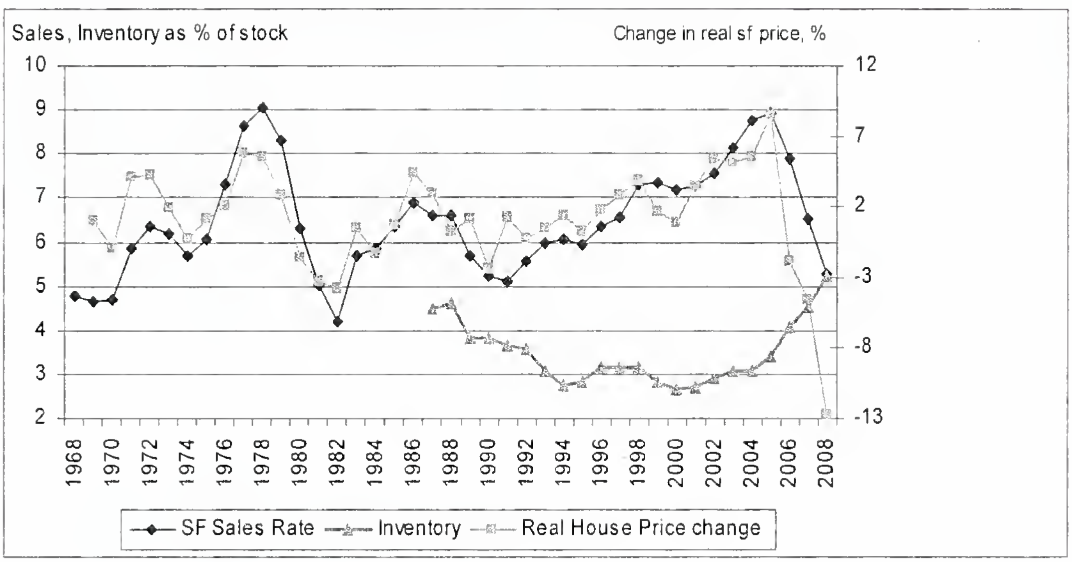
ABSTRACT

This paper examines the strong positive correlation that exists between the volume of housing sales and housing prices. We first closely examine gross housing flows in the US and divide sales into two categories: transactions that involve a change or choice of tenure, as opposed to owner-to-owner churn. The literature suggests that the latter generates a positive sales-to-price relationship, but we find that the former actually represents the majority of transactions. For these we hypothesize that there is a negative prices-to-sales relationship. This runs contrary to a different literature on liquidity constraints and loss aversion. Empirically, we assemble a large panel data base for 101 MSA spanning 25 years. Our results are strong and robust. Underneath the correlation lies a pair of Granger causal relationships exactly as hypothesized: higher sales cause higher prices, but higher prices causes lower sales. The two relationships between sales and prices together provide a more complete picture of the housing market – suggesting the strong positive correlation in the data results from frequent shifts in the price-to-sales schedule. Many such shifts historically occur from changing credit conditions.

I. Introduction.

As shown in Figure 1 below, there is a strong positive correlation between housing sales (expressed as a percent of all owner households) and the movement in housing prices (R^2=.66). On the surface the relationship looks to be close to contemporaneous. There is also a somewhat less obvious negative relationship between prices and the shorter series on the inventory of owner units for sale (R^2=.51). A number of authors have offered explanations for these relationships, in particular that between prices and sales.

Figure I: US Housing Sales, Prices, Inventory



In one camp, there is a growing literature of models describing home owner "churn" in the presence of search frictions [Wheaton (1990), Berkovec and Goodman (1996), Lundberg and Skedinger (1999)]. In these models, buyers become sellers – there are no entrants or exits from the market. In such a situation the role of prices is complicated by the fact that if participants pay higher prices, they also receive more upon sale. It is the transaction cost of owning 2 homes (during the moving period) that grounds prices. If prices are high, the transaction costs can make trading expensive enough to erase the original gains from moving. In this environment Nash-bargained prices move almost inversely to expected sales times – equal to the vacant inventory divided by the sales flow. In these models, both the inventory and sales churn are exogenous. Following Pissarides (2000) if the matching rate is exogenous or alternatively of specific form, the sales time will be shorter with more sales churn and prices therefore higher. Hence greater sales cause higher prices. Similarly greater vacancy (inventory) raises sales times and causes lower prices.

There are also a series of papers which propose that negative changes in prices will subsequently generate lower sales volumes. This again is a positive relationship between the two variables, but with opposite causality. The first of these is by Stein (1995) followed by Lamont and Stein (1999) and then Chan (2001). In these models, liquidity constrained consumers are again moving from one house to another ("churn") and must make a down payment in order to purchase housing. When prices decline consumer equity does likewise and fewer households have the remaining down payment to make the lateral move. As prices rise, equity recovers and so does market liquidity. Relying instead on behavior economics, Genesove and Mayer (2001) and then Englehardt (2003) show empirically that sellers who would experience a loss if they sell set higher reservations than those who would not experience a loss. With higher reservations, the market as a whole would see lower sales if more and more sellers experience loss aversion as prices continue to drop.

In this paper we try to unravel the relationship between housing prices and housing sales, and in addition, the housing inventory. First, we carefully examine gross housing flows in the AHS for the 11 (odd) years in which the survey is conducted. We find the following.

1). There generally are *more purchases* of homes by renters or new households than there are by existing owners. Hence the focus in the literature on own-to-own trades does *not* characterize the *majority* of housing sales transactions.

2). The yearly change in the homeownership rate is highly correlated negatively with housing prices. In years when prices are high, flows into renting grow faster than flows into owning and homeownership starts to decline. When prices are low, net rent-to-own moves increase as does homeownership.

3). We also examine which flows add to the inventory of for-sale units (called LISTS) and which subtract (called SALES). Own-to-own moves, for example do both. We show that the movements in inventory are also positively correlated with price. When prices are high LISTS increase relative to SALES, the inventory grows, and when prices are low, the reverse happens.

4). This leads us to hypothesize that there is joint causality between sales and prices. Owner churn generates a positive schedule between sales and prices as suggested by frictional market theory. At the same time, inter-tenure transitions should lead to a negative schedule. Along the latter, when prices are high sales decrease, lists increase and the inventory starts to grow. In equilibrium, the overall housing market should rest at the intersection of these two schedules.

To test these ideas we assemble a US panel data base of 101 MSA across 25 years. This data is from the NAR and OFHEO. The NAR inventory data is too scattered and short to be included in the panel so our empirics are limited to testing just the hypothesized relationships between sales and prices. Here we find:

5). Using a wide range of model specifications and tests of robustness housing sales *positively* "Granger cause" subsequent housing price movements. This reinforces the relationship posited in frictional search models.

6). There is equally strong empirical support showing that prices *negatively* "Granger cause" subsequent housing sales. This relationship is exactly the opposite of that posited by theories of liquidity constraints and loss aversion, but is consistent with our hypothesis regarding inter-tenure choices.

Our paper is organized as follows. In section II we set up an accounting framework for more completely describing gross housing flows from the 2001 AHS. This involves some careful assumptions to adequately document the magnitude of all the inter tenure flows relative to within tenure churn and to household creation/dissolution. In Section III, we illustrate the relationships between these flows and housing prices using the 11 years for which the flow calculations are possible. We also present our hypothesized pair of relationships between sales and prices as well as the relationship of each to the housing inventory. In sections IV through VI we present our empirical analysis of a panel data set between sales and prices across 101 MSA covering the years from 1982-2006. It is here we find conclusive evidence that sales positively "Granger cause" prices and that prices negatively "Granger cause" sales. Our analysis is robust to many alternative specifications and subsample tests. We conclude with some thoughts about future research as well as the outlook for US house prices and sales.

II. US Gross Housing Flows: Sales, Lists, and the Inventory.

Much of the theoretical literature on sales and prices investigates how existing homeowners behave as they try and sell their current home to purchase a new one. This flow is most often referred to as "churn". To investigate how important a role "churn" plays in the ownership market, we closely examine the 2001 American Housing Survey. In "Table 10"of the Survey, respondents are asked what the tenure was of the residence previously lived in – for those that moved during the last year. The total number of moves in this question is the same as the total in "Table 11" – asking about the previous status of the current head (the respondent). In "Table 11" it turns out that 25% of current renters moved from a residence situation in which they were *not* the head (leaving home, divorce, etc.). The fraction is a smaller 12% for owners. What is missing is the joint distribution between moving by the head and becoming a head. The AHS is not strictly able to identify how many current owners moved either a) from another unit they owned b) another unit they rented or c) purchased a house as they became a new or different household.

To generate the full set of flows, we use information in "Table 11" about whether the previous home was headed by the current head, a relative or acquaintance. We assume that all current owner-movers who were also newly created households - were counted in "Table 10" as previous owners. For renters, we assume that all renter-movers that were also newly created households were counted in "Table 10" in proportion to renter-owner households in the full sample. Finally, we use the Census figures that year for the net increase in each type of household and from that and the data on moves we are able to identify household "exits" by tenure. Gross household exits occur mainly through deaths, institutionalization (such as to a nursing home), or marriage.

Focusing on just the owned housing market, the AHS also allows us to account for virtually all of the events that add to the inventory of houses for sale (herein called

LISTS) and all of those transactions that remove houses from the inventory (herein called SALES). There are two exceptions. The first is the net delivery of new housing units. In 2001 the Census reports that 1,242,000 total units were delivered to the for-sale market. Since we have no direct count of demolitions[1] we use that figure also as net and it is counted as additional LISTS. The second is the net purchases of 2nd homes, which count as additional SALES, but about which there is simply little data[2]. In theory, LISTS – SALES should equal the change in the inventory of units for sale. These relationships are depicted in Figure 2 and can be summarized with the identities below (2001 values are included).

SALES = Own-to-Own + Rent-to-Own + New Owner [+ 2nd homes] = 5,281,000
LISTS = Own-to-Own + Own-to-Rent + Owner Exits + New homes = 5,179,000
Inventory Change = LISTS – SALES
Net Owner Change = New Owners – Owner Exits + Rent-to-Own – Own-to-Rent
Net Renter Change = New Renters – Renter Exits + Own-to-Rent – Rent-to-Own
(1)

The only other comparable data is from the National Association of Realtors (NAR), and it reports that in 2001 the inventory of units for sale was nearly stable. The NAR however reports a higher level of sales at 5,641,000. This 7% discrepancy could be explained by repeat moves within a same year since the AHS asks only about the most recent move. It could also represent significant 2nd home sales which again are not part of the AHS move data.

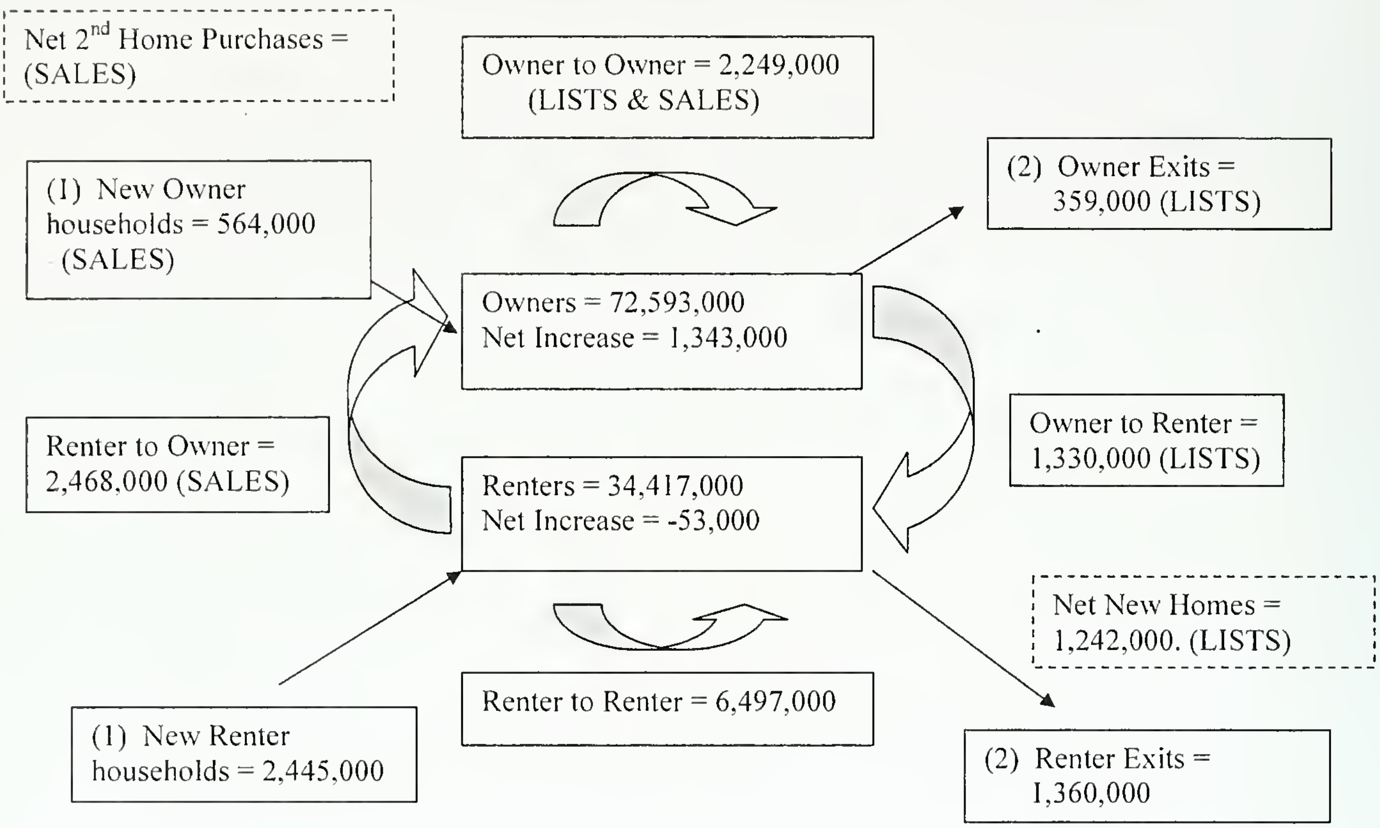
What is most interesting to us is that almost 60% of SALES involve a buyer who is not transferring ownership laterally from one house to another. So called "Churn" is actually a *minority* of sales transactions. These various inter-tenure sales also are the critical determinants of change-in-inventory since "Churn" sales do not affect it. .

---

[1] The growth in stock between 1980-1990-2000 Censuses closely matches summed completions suggesting negligible demolitions over those decades. The same calculation between 1960 and 1970 however suggests removal of 3 million units.

[2] Net second home purchases might be estimated from the product of: the share of total gross home purchases that are second homes (reported by Loan Performance as 15.0%) and the share of new homes in total home purchases (Census, 25%). This would yield 3-4% of total transactions or about 200,000 units. There are no direct counts of the annual change in 2nd home stocks.

Figure 2: US Housing Gross Flows (2001)

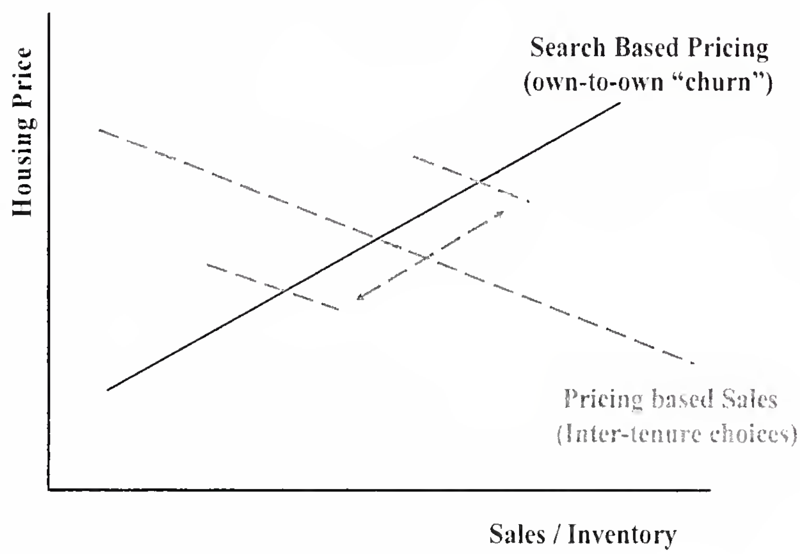


Most inter-tenure SALES would seem to be events that one might expect to be sensitive (negatively) to housing prices. When prices are high presumably new created owner household formation is discouraged or at least deflected into new renter household formation. Likewise moves which involve changes in tenure from renting to owning also should be negatively sensitive to house prices. Both result because higher prices simply make owning a house less affordable. At this time we are agnostic about how net 2nd home sales are related to prices.

On the other side of Figure 2, most of the events generating LISTS should be at least somewhat positively sensitive to price. New deliveries certainly try to occur when prices are high, and such periods would be appropriate for any owners who wish or need to "cash out", consume equity or otherwise switch to renting. At this time we are still seeking a direct data source which investigates in more detail what events actually generate the own-to-rent moves. Thus the flows in and out of homeownership in Figure 2 suggest that when prices are high sales likely decrease, lists increase and the inventory grows.

These events would easily generate a downward sloping schedule between prices and sales such as depicted in Figure 3 below – in compliment to the upward schedule developed by theorists for owner occupied churn. Figure 3 presents a more complete picture of the housing market than the models of Stein, Wheaton, or Berkovec and Goodman – since it accounts for the very large role of inter-tenure mobility as well as for owner churn.

FIGURE 3: Housing Market Equilibrium(s)

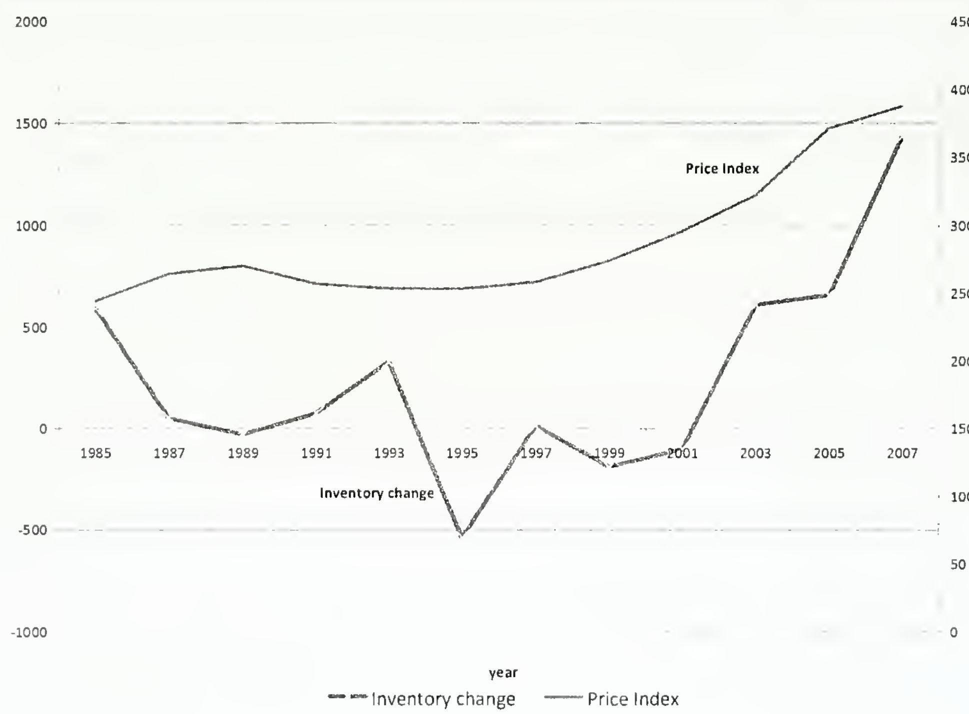


III. Further AHS Empirical Analysis.

Unfortunately the gross flows in Figure 2 can only be assembled for the 11 years in which the AHS has undertaken its survey. These are the odd years from 1985 through

2007.[3] In Appendix III we present all of the calculated flows for each of these 11 years along with the OFHEO price index. The number of time series observations is not much to work with so instead we just illustrate some graphs. In Figure 4, we show house prices against the calculated change in inventory. This is LISTS-SALES where each of these is calculated using the set of identies in (1). There is a strong positive relationship [R^2=.53]. When prices are high LISTS rise, SALES fall and the inventory grows.

Figure 4: Prices versus Inventory Change (LISTS-SALES)

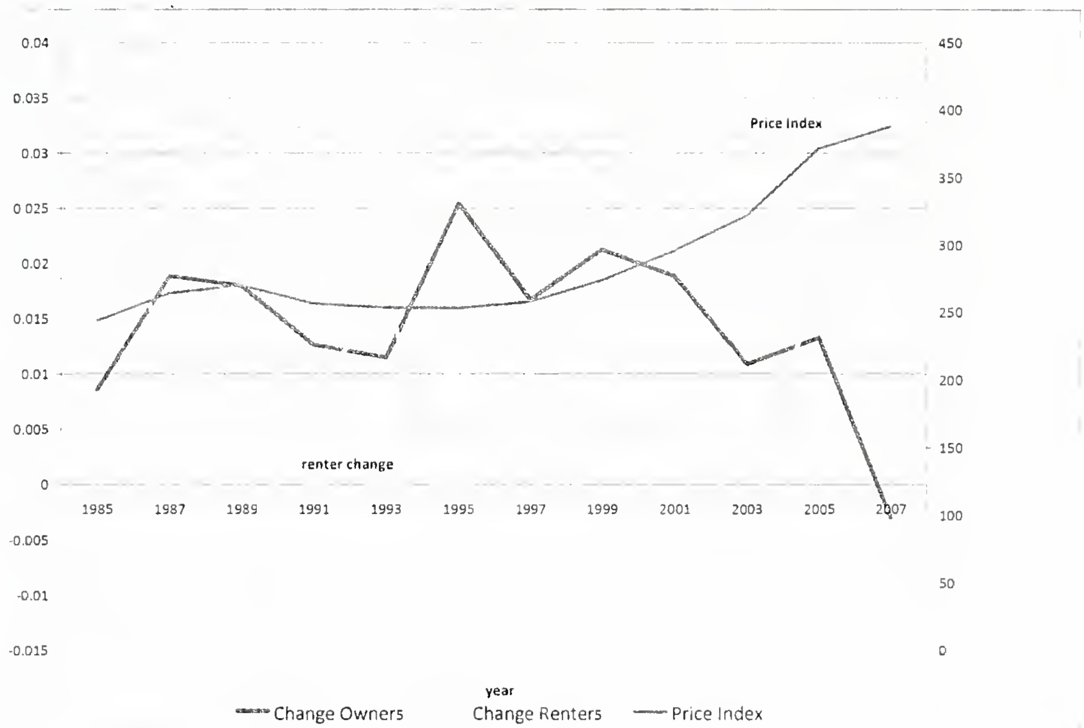


In Figure 5, we examine the percentage change in the number of renters and owners in each of the 11 years – again with respect to prices. Here there is an inverse relationship between prices and the increase in owners [R^2=.48] and a positive relationship between prices and the increase in renters [R^2=.29]. When prices are high, the number of renters seems to rise relative to owners and the opposite when prices are low. Thus there is a parallel negative relationship between prices and the change in the

[3] Prior to 1985, the AHS used different definitions of residence, headship and moving, so the surveys are not comparable with the more recent data.

homeownership rate. While these correlations are based on only 11 observations – they at least span a longer 22 year period.

Figure 5: Prices versus Tenure Changes



IV. Metropolitan Sales and Price Panel Data.

To more carefully study the relationship(s) between housing sales and housing prices we have assembled a large panel data base covering 101 MSA and the years 1982 through 2006.[4] While far more robust than an aggregate US time series, examining

[4]There have been a few recent attempts test whether the relationship between movements in sales and prices support one, or the other, or both theories described previously. Leung, Lau, and Leong (2002) undertake a time series analysis of Hong Kong Housing and conclude that stronger Granger Causality is found for sales driving prices rather than prices driving sales. Andrew and Meen (2003) examine a UK Macro time series using a VAR model and conclude that transactions respond to shocks more quickly than prices, but do not necessarily "Granger Cause" price responses. Both studies are hampered by limited observations.

annual data at the metropolitan level does have a limitation, however, since it cannot use Census or AHS data. The latter contain more detail about the sources of sales and moves, but the Census is available only every decade and the AHS sample is just too small to generate any reliable flows at the MSA level.

For sales data, the only other consistent source is that provided by the National Association of Realtors (NAR). The NAR data is for single family units only (it excludes condominium sales in the MSA series), but is available for each MSA over the full period from 1980 to 2006.[5] To standardize the sales data, raw sales were compared with annual Census estimates of the number of total households in those markets. Dividing single family sales by total households we get a very crude sales rate for each market. In 1980 this calculated sales rate varied between 1.2% and 5.1% across our markets with a national average value of 2.8%. By contrast, in the 1980 census, 8.1% of owner occupied households had moved in during the last year. By 2000, the ratio of national NAR single family sales to total households had risen to 4.9%, while the Census owner mobility rate just inched up to 8.9%. Of course our crude calculated average sales rates should always be lower than the census reported owner mobility rates since the former excludes condo transactions and non-brokered sales. In addition we are dividing by total households rather than just single family owner-occupied households. Separate renter/owner single family household series at *yearly frequency* are not available for all metropolitan markets.

The price data we use is the OFHEO repeat sales series [Baily, Muth, Nourse (1963)]. This data series has recently been questioned for not factoring out home improvements or maintenance and for not factoring in depreciation and obsolescence [Case, Pollakowski, Wachter (1991), Harding, Rosenthal, Sirmans (2007)]. These omissions could generate a significantly bias in the long term trend of the OFEHO series. That said we are left with what is available, and the OFHEO index is the most consistent series available for most US markets over a long time period. The only alternative is to purchase similar indices from CSW/FISERV, although they have most of the same methodological issues as the OFHEO data.

---

[5] NAR data on the inventory of units for sale is shorter, and available only for only a smaller sample of larger metropolitan areas. Hence we exclude it from the analysis.

In Figures 6 and 7 we illustrate the yearly NAR sales rate data, along with the constant dollar OFHEO price series – both in levels and differences - for two markets that exhibit quite varied behavior, Atlanta and San Francisco. Over this time frame, Atlanta's constant dollar prices increase very little while San Francisco's increased almost 200%. San Francisco prices, however, exhibit far greater price volatility. Atlanta's average sales rate is close to 4% and roughly *doubles* over 1980-2006, while San Francisco's is almost half of that (2.6%) and increases by only about 50%. These trends illustrate the typical range of patterns seen across our sample of 101 metropolitan areas. In appendix I we present the summary statistics for each market's price and sales rate series. In virtually all markets there is a long term positive trend in the sales rate, as well as in real house prices.

Figure 6: Atlanta Sales, Prices

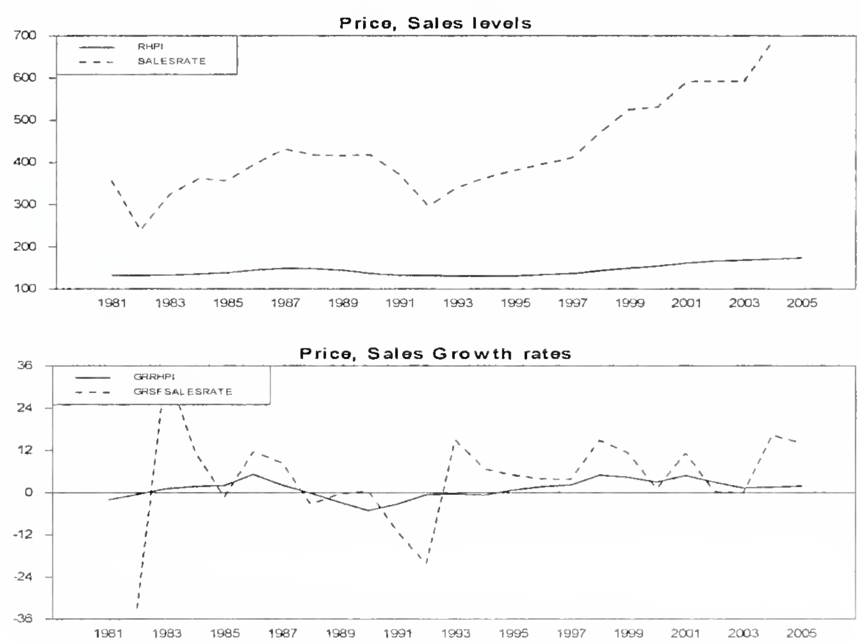
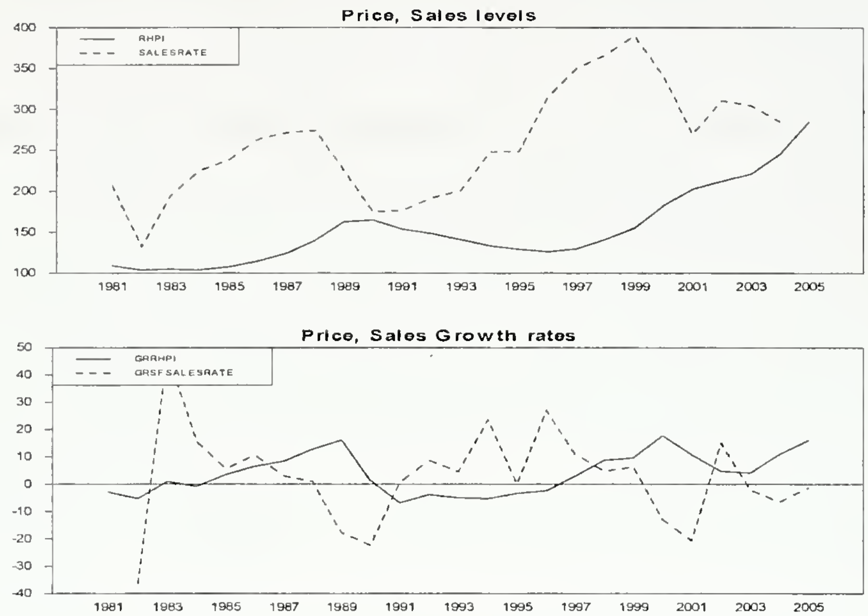


Figure 3: San Francisco Sales, Prices



Given the persistent trends in both series it is important to test more formally for series stationarity. There are two tests available for use with panel data. In each, the null hypothesis is that *all* of the individual series have unit roots and are non stationary. Levin-Lin (1993) and Im-Persaran-Shin (2002) both develop a test statistic for the sum or average coefficient of the lagged variable of interest – across the individuals (markets) within the panel. The null is that all or the average of these coefficients is not significantly different from unity. In Table 1 we report the results of this test for both housing price and sale rate levels, as well as a 2nd order stationarity test for housing price and sales rate changes.

TABLE 1: Stationarity tests

RHPI (Augmented by 1 lag)

Levin Lin's Test	Coefficient	T Value	T-Star	P>T
Levels	-0.10771	-18.535	0.22227	0.5879
First Difference	-0.31882	-19.822	-0.76888	0.2210

IPS test	T-Bar	W(t-bar)		P>T
Levels	-1.679	-1.784		0.037
First Difference	-1.896	-4.133		0.000

SFSALESRATE (Augmented by 1 lag)

Levin Lin's Test	Coefficient	T Value	T-Star	P>T
Levels	-0.15463	-12.993	0.44501	0.6718
First Difference	-0.92284	-30.548	-7.14975	0.0000
IPS test	T-Bar	W(t-bar)		P>T
Levels	-1.382	1.426		0.923
First Difference	-2.934	-15.377		0.000

With the Levin-Lin test we cannot reject the null (non-stationarity) for either house price levels or differences. In terms of the sales, we can reject the null for differences in sales rate, but not for levels. The IPS test (which is argued to have more power) rejects the null for house price levels and differences and for sales rate differences. In short, both variables would seem to be stationary in differences, but levels are more problematic and likely non-stationary.

V. Panel Estimations.

Our panel approach uses a well-known application of Granger-type analysis. We will ask how significant lagged sales are in a panel model of prices which uses lagged prices and then several conditioning variables. The conditioning variables we choose are market area employment, and national mortgage rates. The companion model is to ask how significant lagged prices are in a panel model of sales using lagged sales and the same conditioning variables. This pair of model is shown (2)-(3).

$$P_{i,T} = \alpha_0 + \alpha_1 P_{i,T-1} + \alpha_2 S_{i,T-1} + \beta' X_{i,T} + \delta_i + \varepsilon_{i,T} \qquad (2)$$

$$S_{i,T} = \gamma_0 + \gamma_1 S_{i,T-1} + \gamma_2 P_{i,T-1} + \lambda' X_{i,T} + +\eta_i + \varepsilon_{i,T} \qquad (3)$$

In our case there is significant concern about the stationarity of both price and sales rate levels. This same concern should not be present for differences. Hence we will need to estimate the model in first differences as well as levels – as outlined in equations (4) and (5).[6]

$$\Delta P_{i,T} = \alpha_0 + \alpha_1 \Delta P_{i,T-1} + \alpha_2 \Delta S_{i,T-1} + \beta' \Delta X_{i,T} + +\delta_i + \varepsilon_{i,T} \tag{4}$$

$$\Delta S_{i,T} = \gamma_0 + \gamma_1 \Delta S_{i,T-1} + \gamma_2 \Delta P_{i,T-1} + \lambda' \Delta X_{i,T} + +\eta_i + \varepsilon_{i,T} \tag{5}$$

In panel VAR models with individual heterogeneity there exists a specification issue. Equations (4) and (5) or (2) and (3) will have an error term that is correlated with the lagged dependent variables [Nickell, (1981)]. OLS estimation will yield coefficients that are both biased and also that are not consistent in the number of cross-section observations. Consistency occurs only in the number of time series observations. Thus estimates and any tests on the parameters of interest (the α and γ) may not be reliable. These problems might not be serious in our case since we have 26 time series observations (more than many panel models). To be on the safe side, however, we also estimated the equations following an estimation strategy by Holtz-Eakin et al. As discussed in Appendix II, this amounts to using 2-period lagged values of sales and prices as instruments with GLS estimation.

From either estimates, we conduct a "Granger" causality test. Since we are only testing for a single restriction, the t statistic is the square root of the F statistic that would be used to test the hypothesis in the presence of a longer lag structure (Greene, 2003). Hence, we can simply use a t test (applied to the α_2 and γ_2) as the check of whether changes in sales "Granger cause" changes in price and vice versa.

In table 2 we report the results of equations (2) through (5) in each set of rows. The first column uses OLS estimation, the second the Random Effects IV estimates from Holtz-Eakin et al. The first set of equations is in levels, while the second set of rows reports the results using differences. In all Tables, variable names are self evident and differences are indicated with the prefix GR. Standard errors are in parenthesis.

Among the levels equations, we first notice that the two conditioning variables, the national mortgage rate and local employment have the wrong signs in two cases. The mortgage interest rate in the OLS price levels equation and local employment in the IV

[6] In (3) and (4) the fixed effects are cross-section trends rather than cross section levels as in (1) and (2)

sales rate equation are miss-signed. There is also an insignificant employment coefficient in the OLS sales rate equation (despite almost 2500 observations). Another troublesome result is that the price levels equation has excess "momentum" – lagged prices have a coefficient greater than one. Hence prices (levels) can grow on their own without necessitating any increases in fundamentals, or sales. We suspect that these two anomalies are likely the result of the non-stationary feature to both the price and sales series when measured in levels. Interestingly, the two estimation techniques yield quite similar coefficients – as might be expected with a larger number of time series observations.

When we move to the results of estimating the equations in differences all of these issues disappear. The lagged price coefficients are small so the price equations are stable in the 2nd degree, and the signs of all coefficients are both correct – and highly significant.

As to the question of causality, in every price or price growth equation, lagged sales or growth in sales is always significantly positive. Furthermore in every sales rate or growth in sales rate equation, lagged prices (or its growth) are also always significant. Hence there is clear evidence of joint causality, *but the effect of lagged prices on sales is always of a negative sign.* Holding lagged sales (and conditioning variables) constant, a year after there is an increase in prices – sales fall. The is the opposite of that predicted by theories of loss aversion or liquidity constraints, but consistent with our hypothesis.

TABLE 2: Sales-Price VAR

	Fixed Effects	E Holtz-Eakin estimator
Levels		
Real Price (Dependent Variable)		
Constant	-25.59144**	-12.47741**
	(2.562678)	(2.099341)
Real Price (lag 1)	1.023952**	1.040663**
	(0.076349)	(0.0076326)
Sales Rate (lag 1)	3 33305**	2.738264**
	(0.2141172)	(0.2015346)
Mortgage Rate	0.3487804**	-0.3248508**
	(0.1252293)	(0.1209959)
Employment	0.0113145**	0.0015689**
	(0.0018579)	(0.0003129)

Sales Rate (Dependent Variable)		
Constant	2.193724**	1.796734**
	(0.1428421)	(0.1044475)
Real Price (lag 1)	-0.0063598**	-0.0059454**
	(0.0004256)	(0.0004206)
Sales Rate (lag 1)	0.8585273**	0.9370184**
	(0.0119348)	(0.0080215)
Mortgage	-0.063598**	-0.0664741**
	(0.0069802)	(0.0062413)
Employment	-0.0000042	-0.0000217**
	(0.0001036)	(0.0000103)
First Difference		
GR Real Price (Dependent Variable)		
Constant	-0.4090542**	-0.49122**
	(0.1213855)	(0.1221363)
GR Real Price (Lag 1)	0.7606135**	0.8008682**
	(0.0144198)	(0.0148136)
GR Sales Rate (Lag 1)	0.0289388**	0.1826539**
	(0.0057409)	(0.022255)
GR Mortgage Rate	-0.093676**	-0.08788**
	(0.097905)	(0.0102427)
GR Employment	0.3217936**	0.1190925**
	(0.0385593)	(0.048072)
GR Sales Rate (Dependent Variable)		
Constant	0.7075247	1.424424**
	(0.3886531)	(0.3710454)
GR Real Price (Lag1)	-0.7027333**	-0.8581478**
	(0.0461695)	(0.0556805)
GR Sales Rate (Lag 1)	0.0580555**	0.0657317**
	(0.0183812)	(0.02199095)
GR Mortgage Rate	-0.334504**	-0.307883**
	(0.0313474)	(0.0312106)
GR Employment	1.167302**	1.018177**
	(0.1244199)	(0.1120497)

** indicates significance at 5%.

We have experimented with these models using more than a single lag, but qualitatively the results are the same. In levels, the price equation with two lags becomes dynamically stable in the sense that the sum of the lagged price coefficients is less than one. As to causal inference, the sum of the lagged sales coefficients is positive, highly significant, and passes the Granger F test. In the sales rate equation, the sum of the two lagged sales rates is virtually identical to the single coefficient above and the lagged price levels are again significantly negative (in their sum). Collectively higher lagged prices "Granger cause" a reduction in sales. We have similar conclusions when two lags are used in the differences equations, but in differences, the 2nd lag is always insignificant.

As a final test, we investigate a relationship between the *growth* in house prices and the *level* of the sales rate. In the search theoretic models sales rates determine price levels, but if prices are slow to adjust, the impact of sales might better show up on price changes. Similarly the theories of loss aversion and liquidity constraints relate price changes to sales levels. While the mixing of levels and changes in time series analysis is generally not standard, this combination of variables is also the strong empirical fact shown in Figure 1. In Table 3 price changes are tested for Granger causality against the level of sales (as a rate).

TABLE 3: Sales-Price Mixed VAR

Differences and Levels	Fixed Effects	E Holtz-Eakin estimator
GR Real Price (Dependent Variable)		
Constant	-6.61475**	-1.431187**
	(0.3452743)	(0.2550279)
GR Real Price (lag 1)	0.5999102**	0.749431**
	(0.0155003)	(0.0141281)
Sales Rate (lag 1)	1.402352**	0.2721678**
	(0.0736645)	(0.0547548)
GR Mortgage Rate	-0.1267573**	-0.0860948**
	(0.0092715)	(0.0095884)
GR Employment	0.5059503**	0.3678023**
	(0.0343458)	(0.0332065)
Sales Rate (Dependent Variable)		
Constant	-0.0348229	0.0358686
	(0.0538078)	(0.0026831)
GR House Price (lag 1)	-0.0334235**	-0.0370619**
	(0.0024156)	(0.0026831)
Sales Rate (lag 1)	1.011515**	1.000989**
	(0.0114799)	(0.0079533)
GR Mortgage Rate	-0.0162011**	-0.0151343**
	(0.0014449)	(0.0014294)
GR Employment	0.0494462**	0.043442**
	(0.0053525)	(0.0049388)

** indicates significance at 5%

In terms of causality, these results are no different than the models estimated either in all levels or all differences. One year after an increase in the *level* of sales, the *growth* in house prices accelerates. Similarly, one year after house price *growth* accelerates the *level* of home sales falls (rather than rises). All conditioning variables are significant and correctly signed and lagged dependent variables have coefficients less than one.

VI. Tests of Robustness.

In panel models it is always a good idea to provide some additional tests of the robustness of results, usually by dividing up either the cross section or time series of the panel into subsets and examining these results as well. Here we perform both tests. First we divide the MSA markets into two groups: so-called "coastal" cities that border either ocean, and "interior" cities that do not. There are 31 markets in the former group and 70 in the latter. The coastal cities are often felt to be those with strong price trends and possibly different market supply behavior. These results are in Table 4. The second test is to divide the sample up by year – in this case we estimate separate models for 1980-1992 and 1993-2006. The year 1992 generally marks the bottom of the housing market from the 1990 recession. These results are depicted in Table 5. Both experiments use just the differences model that seems to provide the strongest results from the previous section.

TABLE 4: Geographic Sub Panels

	Fixed Effects		E Holtz-Eakin estimator	
	Coastal MSA	Interior MSA	Coastal MSA	Interior MSA
GR Real Price (Dependent Variable)				
Constant	-0.6026028 (0.2974425)	-0.274607** (0.1132241)	-0.543562 (0.3332429)	-.338799** .1054476
GR Real Price (Lag 1)	0.7661637** (0.0255794)	0.7731355** (0.0178884)	0.855731** (0.0351039)	.7834749** .0171874
GR Sales Rate (Lag 1)	0.0608857** (0.0141261)	.0094349* (0.0054047)	0.3475212** (0.0573584)	.0799289** .0198759
GR Mortgage Rate	-0.106036** (0.023653)	-.0866954** (0.0092136)	-0.112101** (0.0278593)	-.0776626** .008816
GR Employment	0.5717489** (0.0978548)	.1978858** (0.0359637)	-0.0434497 (0.153556)	.1617733** .0381004

GR Sales Rate (Dependent Variable)				
Constant	2.098906** (0.7412813)	0.0396938** (0.4541917)	3.03388** (0.7426378)	0.8084169* (0.4261651)
GR Real Price (Lag1)	-0.8320889** (0.0637485)	-0.5447358** (0.0637485)	-0.9763902** (0.0798291)	-0.8519448** (0.0919725)
GR Sales Rate (Lag 1)	-0.0004387 (0.0352049)	0.0770193** (0.0216808)	-0.0350817 (0.0402424)	0.1111637** (0.0251712)
GR Mortgage Rate	-0.2536587** (0.0589476)	-0.3772017** (0.0369599)	-0.2390963** (0.0595762)	-0.3323406** (0.036746)
GR Employment	1.265286** (0.2438722)	1.172214** (0.1442662)	1.102051** (0.2223687)	1.03251** (0.1293764)

Note:

a) *- 10 percent significance. **- 5 percent significance.
b) MSAs denoted coastal are MSAs near the East or West Coast (see Appendix I).
c) MSAs denoted interior are MSAs that are not located at the East or West Coast.

In Table 6, the results of Table 4 hold up remarkably strong when the panel is divided by region. The coefficient of sales rate (growth) on prices is always significant although so-called "costal" cities have larger coefficients. In the equations of price (growth) on sales rates, the coefficients are always significant, and the point estimates are very similar as well. The negative effect of prices on sales rates is completely identical across the regional division of the panel sample. It should be pointed out that all of the instruments are correctly signed and significant as well.

The conclusion is the same when the panel is split into two periods (Table 5). The coefficients of interest are significant and of similar magnitudes across time periods, and all instruments are significant and correctly signed as well. The strong negative impact of prices on sales clearly occurred during 1982-1992 as well as over the more recent period from 1993-2006. With fewer time series observations in each of the (sub) panels in Table 7, the Holtz-Eakin estimates are now sometimes quite different than the OLS results.

TABLE 5: Time Subpanels

	Fixed Effects		E Holtz-Eakin estimator	
	1982-1992	1993-2006	1982-1992	1993-2006
GR Real Price (Dependent Variable)				
Constant	-2.63937**	-0.1053808	-1.237084**	-0.2731544

	(0.2362837)	(0.1453335)	(0.2879418)	(0.1943765)
GR Real Price (Lag 1)	0.5521216** (0.0271404)	0.9364014** (0.0183638)	0.6752733** (0.0257512)	0.9629539** (0.0196925)
GR Sales Rate (Lag 1)	0.0194498** (0.0073275)	0.0363384** (0.0097935)	0.1622147** (0.0307569)	0.0874362 ** (0.0307703)
GR Mortgage Rate	-0.2315352** (0.0193262)	-0.0707981** (0.0116032)	-0.1432255** (0.0244255)	-0.0812995** (0.0163056)
GR Employment	0.6241497** (0.063533)	0.4310861** (0.0501575)	0.157348* (0.0910416)	0.3441402** (0.0493389)
GR Sales Rate (Dependent Variable)				
Constant	-6.269503** (0.9018295)	4.398222** (0.447546)	-4.898023** (0.8935038)	3.00473** (0.4587499)
GR Real Price (Lag1)	-0.8795382** (0.1035874)	-0.5704616** (0.0565504)	-1.080492** (0.1243784)	-0.4387881** (0.066557)
GR Sales Rate (Lag 1)	0.0056823 (0.027967)	-0.025242 (0.0301586)	-0.0035275 (0.0350098)	0.066557 (0.029539)
GR Mortgage Rate	-0.5636095** (0.0737626)	-0.1934848** (0.0357313)	-0.550748** (0.0819038)	-0.2720118** (0.0420076)
GR Employment	2.608423** (0.2424878)	0.4856197** (0.154457)	2.026295** (0.2237316)	0.7631351** (0.1325586)

Note:

a) Column labeled under 1982-1992 refer to the results using observations that span those years..
b) Column labeled under 1993-2006 refer to the results using observations that span those years.

VII. Conclusions

We have shown that the causal relationship from prices-to-sales is actually negative – rather than positive. Our empirics are quite strong. As an explanation, we have argued that actual flows in the housing market are remarkably large between tenure groups – and that a negative price-to-sales relationship makes sense as a reflection of these inter-tenure flows. Higher prices lead more households to choose renting than owning and these flows decrease SALES. Higher prices also increase LISTS and so the inventory grows. When prices are low, entrants exceed exits into ownership, SALES increase, LISTS decline as does the inventory.

Our empirical analysis also overwhelmingly supports the positive sales-to-price relationship that emerges from search-based models of housing churn. Here, a high sales/inventory ratio causes higher prices and a low ratio generates lower prices. Thus we arrived at a more complete description of the housing market at equilibrium – as shown with the two schedules in Figure 3.

Figure 3 offers a compelling explanation for why in the data, the simple price-sales correlation is so overwhelmingly positive. Over time it must be the "price based sales" schedule that is shifting up and down. Remember that this schedule is derived mainly from the decision to enter or exit the ownership market. Easy credit availability and lower mortgage rates, for example would shift the schedule up (or out). For the same level of housing prices, easier credit increases the rent-to-own flow, decreases the own-to-rent flow, and encourages new households to own. Sales expand and the inventory contracts. The end result of course is a rise in both prices as well as sales. Contracting credit does the reverse. In the post WWII history of US housing, such credit expansions and contractions have indeed tended to dominate housing market fluctuations [Capozza, Hendershott, Mack (2004)].

Figure 3 also is useful for understanding the current turmoil in the housing market. Easy mortgage underwriting from "subprime capital" greatly encouraged expanded homeownership from the mid 1990s through 2005 [Wheaton and Nechayev, (2007)]. This generated an outward shift in the price-based-sales schedule. Most recently, rising foreclosures have expanded the rent-to-own flow and shifted the "price based sales" schedule back inward. This has decreased both sales and prices. Preventing foreclosures through credit amelioration theoretically would move the schedule upward again, but so could any countervailing policy of easing mortgage credit. It is interesting to speculate on whether there might be some policy that would shift the "search based pricing" schedule upward. This would restore prices, although it would not increase sales. For example some policy to encourage interest-free bridge loans would certainly make it easier for owners to "churn". Likewise some form of home sales insurance might reduce the risk associated with owning two homes. That said, such policies would seem to be a less direct way of assisting the market versus some stimulus to the "price-based-sales" schedule.

REFERENCES

Andrew, M. and Meen, G., 2003, "House price appreciation, transactions and structural change in the British housing market: A macroeconomic perspective", *Real Estate Economics*, 31, 99-116.

Baily, M.J., R.F. Muth, and H.O. Nourse, 1963, "A Regression Method for Real Estate Price Index Construction", *Journal of the American Statistical Association*, 58, 933-942.

Berkovec, J.A. and Goodman, J.L. Jr., 1996, "Turnover as a Measure of Demand for Existing Homes", *Real Estate Economics*, 24 (4), 421-440.

Case, B., Pollakowski, H., and Susan M. Wachter, 1991. "On Choosing among Housing Price Index Methodologies," *AREUEA Journal*, 19, 286-307.

Capozza, D., Hendershott, P., and Charlotte Mack, 2004, "An Anatomy of Price Dynamics in Illiquid Markets: Analysis and Evidence from Local Housing Markets," *Real Estate Economics*, 32:1, 1-21.

Chan, S., 2001, "Spatial Lock-in: Do Falling House Prices Constrain Residential Mobility?", *Journal of Urban Economics*, 49, 567-587.

Engelhardt, G. V., 2003, "Nominal loss aversion, housing equity constraints, and household mobility: evidence from the United States." *Journal of Urban Economics*, 53 (1), 171-195.

Genesove, D. and C. Mayer, 2001, "Loss aversion and seller behavior: Evidence from the housing market." *Quarterly Journal of Economics*, 116 (4), 1233-1260.

Greene, W.H., 2003, *Econometric Analysis*, (5th Edition), Prentice Hall, New Jersey.

Harding, J., Rosenthal, S., and C.F.Sirmans, 2007, "Depreciation of Housing Capital, maintenance, and house price inflation…", *Journal of Urban Economics*, 61,2, 567-587.

Holtz-Eakin, D., Newey, W., and Rosen, S.H, 1988, "Estimating Vector Autoregressions with Panel Data", *Econometrica*, Vol. 56, No. 6, 1371-1395.

Kyung So Im, M.H. Pesaran, Y. Shin, 2002, "Testing for Unit Roots in Heterogeneous Panels", Cambridge University, Department of Economics

Lamont, O. and Stein, J., 1999, "Leverage and House Price Dynamics in U.S. Cities." *RAND Journal of Economics*, 30, 498-514.

Levin, Andrew and Chien-Fu Lin, 1993, "Unit Root Tests in Panel Data: new results." *Discussion Paper No. 93-56*, Department of Economics, University of California at San Diego.

Leung, C.K.Y., Lau, G.C.K. and Leong, Y.C.F., 2002, "Testing Alternative Theories of the Property Price-Trading Volume Correlation." *The Journal of Real Estate Research*, 23 (3), 253-263.

Nickell, S., 1981, "Biases in Dynamic Models with Fixed Effects," *Econometrica*, Vol. 49, No. 6. pp. 1417-1426.

Per Lundborg, and Per Skedinger, 1999, "Transaction Taxes in a Search Model of the Housing Market", *Journal of Urban Economics,* 45, 2, 385-399.

Pissarides, Christopher, 2000, *Equilibrium Unemployment Theory*, 2^{nd} edition, MIT Press, Cambridge, Mass.

Stein, C. J., 1995, "Prices and Trading Volume in the Housing Market: A Model with Down-Payment Effects," *The Quarterly Journal Of Economics*, 110(2), 379-406.

Wheaton, W.C., 1990, "Vacancy, Search, and Prices in a Housing Market Matching Model," *Journal of Political Economy*, 98, 1270-1292

Wheaton, W.C., and Gleb Nechayev 2008, "The 1998-2005 Housing 'Bubble' and the Current 'Correction': What's different this time?" *Journal of Real Estate Research*, 30,1, 1-26.

APPRENDIX I: Sales, Price Panel Statistics

Market Code	Market	Average GRRHPI (%)	Average GREMP (%)	Average SFSALES RATE	Average GRSALES RATE (%)
1	Allentown*	2.03	1.10	4.55	4.25
2	Akron	1.41	1.28	4.79	4.96
3	Albuquerque	0.59	2.79	5.86	7.82
4	Atlanta	1.22	3.18	4.31	5.47
5	Austin	0.65	4.23	4.36	4.86
6	Bakersfield*	0.68	1.91	5.40	3.53
7	Baltimore*	2.54	1.38	3.55	4.27
8	Baton Rouge	-0.73	1.77	3.73	5.26
9	Beaumont	-1.03	0.20	2.75	4.76
10	Bellingham*	2.81	3.68	3.71	8.74
11	Birmingham	1.28	1.61	4.02	5.53
12	Boulder	2.43	2.54	5.23	3.45
13	Boise City	0.76	3.93	5.23	6.88
14	Boston MA*	5.02	0.95	2.68	4.12
15	Buffalo	1.18	0.71	3.79	2.71
16	Canton	1.02	0.79	4.20	4.07
17	Chicago IL	2.54	1.29	4.02	6.38
18	Charleston	1.22	2.74	3.34	6.89
19	Charlotte	1.10	3.02	3.68	5.56
20	Cincinnati	1.09	1.91	4.87	4.49
21	Cleveland	1.37	0.77	3.90	4.79
22	Columbus	1.19	2.15	5.66	4.61
23	Corpus Christi	-1.15	0.71	3.42	3.88
24	Columbia	0.80	2.24	3.22	5.99
25	Colorado Springs	1.20	3.37	5.38	5.50
26	Dallas-Fort Worth-Arlington	-0.70	2.49	4.26	4.64
27	Dayton OH	1.18	0.99	4.21	4.40
28	Daytona Beach	1.86	3.06	4.77	5.59
29	Denver CO	1.61	1.96	4.07	5.81
30	Des Moines	1.18	2.23	6.11	5.64
31	Detroit MI	2.45	1.42	4.16	3.76
32	Flint	1.70	0.06	4.14	3.35
33	Fort Collins	2.32	3.63	5.82	6.72
34	Fresno CA*	1.35	2.04	4.69	6.08
35	Fort Wayne	0.06	1.76	4.16	7.73
36	Grand Rapids MI	1.59	2.49	5.21	1.09
37	Greensboro NC	0.96	1.92	2.95	7.22

38	Harrisburg PA	0.56	1.69	4.24	3.45
39	Honolulu	3.05	1.28	2.99	12.66
40	Houston	-1.27	1.38	3.95	4.53
41	Indianapolis IN	0.82	2.58	4.37	6.17
42	Jacksonville	1.42	2.96	4.60	7.23
43	Kansas City	0.70	1.66	5.35	5.17
44	Lansing	1.38	1.24	4.45	1.37
45	Lexington	0.67	2.43	6.23	3.25
46	Los Angeles CA*	3.51	0.99	2.26	5.40
47	Louisville	1.48	1.87	4.65	4.53
48	Little Rock	0.21	2.22	4.64	4.63
49	Las Vegas	1.07	6.11	5.11	8.14
50	Memphis	0.46	2.51	4.63	5.75
51	Miami FL	1.98	2.93	3.21	6.94
52	Milwaukee	1.90	1.24	2.42	5.16
53	Minneapolis	2.16	2.20	4.39	4.35
54	Modesto*	2.81	2.76	5.54	7.04
55	Napa*	4.63	3.27	4.35	5.32
56	Nashville	1.31	2.78	4.44	6.38
57	New York*	4.61	0.72	2.34	1.96
58	New Orleans	0.06	0.52	2.94	4.80
59	Ogden	0.67	3.25	4.22	6.08
60	Oklahoma City	-1.21	0.95	5.17	3.66
61	Omaha	0.65	2.03	4.99	4.35
62	Orlando	0.88	5.21	5.30	6.33
63	Ventura*	3.95	2.61	4.19	5.83
64	Peoria	0.38	1.16	4.31	6.93
65	Philadelphia PA*	2.78	1.18	3.52	2.57
66	Phoenix	1.05	4.41	4.27	7.49
67	Pittsburgh	1.18	0.69	2.86	2.75
68	Portland*	2.52	2.61	4.17	7.05
69	Providence*	4.82	0.96	2.83	4.71
70	Port St. Lucie	1.63	3.59	5.60	7.18
71	Raleigh NC	1.15	3.91	4.06	5.42
72	Reno	1.55	2.94	3.94	8.60
73	Richmond	1.31	2.04	4.71	3.60
74	Riverside*	2.46	4.55	6.29	5.80
75	Rochester	0.61	0.80	5.16	1.01
76	Santa Rosa*	4.19	3.06	4.90	2.80
77	Sacramento*	3.02	3.32	5.51	4.94
78	San Francisco CA*	4.23	1.09	2.61	4.73

79	Salinas*	4.81	1.55	3.95	5.47
80	San Antonio	-1.03	2.45	3.70	5.52
81	Sarasota	2.29	4.25	4.69	7.30
82	Santa Barbara*	4.29	1.42	3.16	4.27
83	Santa Cruz*	4.34	2.60	3.19	3.24
84	San Diego*	4.13	2.96	3.62	5.45
85	Seattle*	2.97	2.65	2.95	8.10
86	San Jose*	4.34	1.20	2.85	4.55
87	Salt Lake City	1.39	3.12	3.45	5.72
88	St. Louis	1.48	1.40	4.55	4.82
89	San Luis Obispo*	4.18	3.32	5.49	4.27
90	Spokane*	1.52	2.28	2.81	9.04
91	Stamford*	3.64	0.60	3.14	4.80
92	Stockton*	2.91	2.42	5.59	5.99
93	Tampa	1.45	3.48	3.64	5.61
94	Toledo	0.65	1.18	4.18	5.18
95	Tucson	1.50	2.96	3.32	8.03
96	Tulsa	-0.96	1.00	4.66	4.33
97	Vallejo CA*	3.48	2.87	5.24	5.41
98	Washington DC*	3.01	2.54	4.47	3.26
99	Wichita	-0.47	1.43	5.01	4.39
100	Winston	0.73	1.98	2.92	5.51
101	Worcester*	4.40	1.13	4.18	5.77

Notes: Table provides the average real price appreciation over the 25 years, average job growth rate, average sales rate, and growth in sales rate.
* Denotes "Costal city" in robustness tests.

APPENDIX II

Let $\Delta p_T = [\Delta P_{1T}, ..., \Delta P_{NT}]$ 'and $\Delta s_T = [\Delta S_{1T}, ..., \Delta S_{NT}]$ ', where N is the number of markets. Let $W_T = [e, \Delta p_{T-1}, \Delta s_{T-1}, \Delta X_{i,T}]$ be the vector of right hand side variables, where e is a vector of ones. Let $V_T = [\varepsilon_{1T}, ..., \varepsilon_{NT}]$ be the N x 1 vector of transformed disturbance terms. Let $B = [\alpha_0, \alpha_1, \alpha_2, \beta_1, \delta_1]$ ' be the vector of coefficients for the equation.

Therefore,

$$\Delta p_T = W_T B + V_T \tag{1}$$

Combining all the observations for each time period into a stack of equations, we have,

$$\Delta p = WB + V . \tag{2}$$

The matrix of variables that qualify for instrumental variables in period T will be

$$Z_T = [e, \Delta p_{T-2}, \Delta s_{T-2}, \Delta X_{i,T}], \tag{3}$$

which changes with T.

To estimate B, we premultiply (2) by Z' to obtain

$$Z'\Delta p = Z'WB + Z'V . \tag{4}$$

We then form a consistent instrumental variables estimator by applying GLS to equation (4), where the covariance matrix $\Omega = E\{Z'VV'Z\}$. Ω is not known and has to be estimated. We estimate (4) for each time period and form the vector of residuals for each period and form a consistent estimator, $\widetilde{\Omega}$, for Ω. $\widetilde{B}$, the GLS estimator of the parameter vetor, is hence:

$$\widetilde{B} = [W'Z(\widetilde{\Omega})^{-1}Z'W]^{-1}W'Z(\widetilde{\Omega})^{-1}Z'\Delta p . \tag{5}$$

The same procedure applies to the equation wherein Sales (S) are on the LHS.

APPENDIX III: AHS Data (House Price Data from Census)

year	1985	1987	1989	1991	1993	1995	1997	1999	2001	2003	2005	2007
R change	1061	300	414	266	616	-312	116	-65	-53	-181	665	952
O change	481	1071	1055	762	710	1603	1102	1459	1343	776	978	-221
New Del.	1072.5	1122.8	1026.3	837.6	1039.4	1065.5	1116.4	1270.4	1241.8	1386.3	1635.9	1216.5
New O	537	558	482	473	557	579	409	430	564	501	641	688
New R	2792	2877	2751	2881	2725	2959	2377	2387	2445	2403	2507	2686
RR	7325	7438	7563	7485	7184	7714	7494	6934	6497	6889	7291	7152
OR	1491	1448	1654	1129	1143	1186	1413	1309	1330	1233	1273	1426
OO	1998	2049	1918	1697	1769	1983	2074	2478	2249	2381	2913	2391
RO	2074	2256	2110	1980	2177	2337	2208	2378	2468	2305	2607	2032
O Exits	639	295	-117	562	881	127	102	40	359	797	997	1515
R Exits	1148	1769	1881	1764	1075	2120	1466	1383	1360	1512	508	1128
Lists	5200.5	4914.8	4481.3	4225.6	4832.4	4361.5	4705.4	5097.4	5179.8	5797.3	6818.9	6548.5
Sales	4609	4863	4510	4150	4503	4899	4691	5286	5281	5187	6161	5111
Price	244.1647	264.3485	270.2479	256.9754	253.6429	253.331	258.1007	274.0435	295.7802	322.0829	371.4579	387.985
Real Median House Price	145488.1	156215.7	158258.4	156384.1	156575.9	159199.3	166624.9	175750.3	183404.1	203062.5	232526.1	217900