Preliminary Draft
Not for Quotation
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The Dynamic Structure of Housing Markets

Dennis R. Capozza
University of Michigan Business School
Ann Arbor, MI 48109
Capozza@umich.edu
313 764 1269

Charlotte Mack
University of Michigan
Ann Arbor, MI 48109
CYM@umich.edu

Christopher J. Mayer
Columbia University Business School
New York, NY 10027
CM310@columbia.edu
212 854 3471

Initial draft: June 11, 1997
This draft: December 15, 1997

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We model the dynamics of house values as a second order difference equation which arises from the serial correlation and reversion. We estimate the serial correlation and mean reversion coefficients for a panel data set of 62 metro areas from 1979-1995, using a two stage procedure. The first stage estimates the fundamental house values. In the second stage house values revert to fundamental values. The serial correlation and reversion parameters are shown to vary cross sectionally with city size, income growth, population growth, and construction costs. Serial correlation is higher in metro areas with higher income and population growth and higher construction costs. The results on the speed of reversion suggest that mean reversion is greater in large metro areas and faster-growing cities. The range of parameter estimates for the difference equation for most metro areas lie in the damped oscillation range, i.e., in response to a step change in the fundamental value, actual values overshoot but eventually converge to the fundamental value.

Numerous studies of a variety of asset markets have now documented the existence of short horizon serial correlation and long horizon mean reversion in asset prices. Given the wide variety of methodologies, time periods, countries and asset types in recent studies, the evidence begins to suggest that serial correlation and mean reversion may be pervasive and ubiquitous features of asset markets. Since time series predictability of prices is inconsistent with rational pricing in efficient markets, the evidence is a challenge to this common assumption of economic and financial theory.

The focus of this research is the housing market in the U.S. As has been done for other asset types, earlier studies of housing have documented both serial correlation and mean reversion (Case and Shiller, 1989; Abraham and Hendershott, 1996; Capozza and Seguin, 1996). From these studies and from the observed behavior of housing prices in regional markets, it is clear that the extent of correlation or reversion varies with location. For example, Abraham and Hendershott (1996) document a significant difference in time series properties between coastal and inland cities. The logical question to ask is why regions react differently to economic shocks. This research provides some exploratory empirical results to help resolve these issues.

We use a large panel data set for 62 US metropolitan areas from 1979 to 1995. The data set includes a economic, demographic, and political variables for each of the metro areas. We explore two kinds of hypotheses: information or transaction based explanations and supply based theories. Housing is highly heterogeneous so that participants have difficulty assessing the instantaneous "true" price for any given property. In general (Quan and Quigley, 1991), an optimal "appraisal" weights current and past transactions prices of similar properties. As a result transaction frequency can affect the rate of information dissemination in a housing market. Transaction frequency also affects reservation prices in search models of the housing market (Wheaton, 1991). Whenever economic or demographic variables affect transaction frequency, a metro area may react either faster or with more amplitude to a given economic shock.

Any given positive economic shock will be easier for an area to absorb if the housing stock can be increased quickly and at low cost. Therefore we hypothesize that variables that proxy for the cost and difficulty of adding to the supply of housing should affect the time series properties of housing prices. To preview the conclusions we find evidence that both information dissemination and supply factors influence the dynamics of housing prices.

Previous Literature

Among asset markets, the most heavily researched is the equity market. Two examples include Fama and French (1988) and Poterba and Summers (1988). Using different methodologies both find significant evidence of mean reversion at long horizons. For example, Fama and French conclude that "predictable variation is estimated to be about 40 percent of 3-5 year return variances for portfolios of small firms." Time varying equilibrium expected returns and investor overreaction have been proposed as possible explanations. A recent study that models "fundamental" value using dividends and earnings is Chiang, Davidson and Okunev (1997).

There is a long literature in international trade which explains exchange rate movements as reversion to purchasing power parity (fundamental value). A recent example that uses panel data is Frankel and Rose (1996). They find "strong evidence of mean reversion that is similar to that from long time-series."

Studies of housing that document serial correlation and mean reversion include Case and Shiller (1989), Abraham and Hendershott (1996) and Capozza and Seguin (1996). A recent study that is the first to attempt to explain differences among regions is Lamont and Stein (1996). They find that "where homeowners are more leveraged . . . house prices react more sensitively to city-specific shocks."

Clearly the evidence on the time series properties of asset prices is voluminous, but much less is known about the determinants of these properties. We know that the extent of serial correlation and mean reversion varies among assets and markets but the causes of this variation is not well understood.

Our three contributions are first to provide additional evidence on serial correlation and mean reversion in housing markets using a new methodology and a much larger panel data set than previously. Our results are consistent with earlier estimates but lie at the upper end of earlier estimates. Secondly we analyze the difference equation implied by serial correaltion and mean reversion and show that the estimates for most metro areas lie in the damped cyclical range. Third and most importantly, we model and estimate equations relating the extent of serial correlation and mean reversion to possible determinants. We explore the role of information dissemination, supply constraints, and backward-looking expectation formation on market dynamics.

In the next section we develop the difference equation and the empirical specification. The third section describes the panel data set we use for our estimates and the fourth section discusses the empirical results. The final section concludes with suggestions for future research and policy implications.

Model and Empirical Implementation

The model underlying our estimates incorporates autocorrelation and mean reversion into discrete time. It is assumed that in each time period, *t*, and in each metro area there is a fundamental value for housing that is determined by economic conditions.

$$P_t^* = p(\boldsymbol{X}_t) \tag{1}$$

where P_t^* is the log of real fundamental value in the metro area and $\boldsymbol{X}_t$ is a vector of exogenous explanatory variables.

Value changes are governed by reversion to this fundamental value and by serial correlation according to

$$\Delta P_t = \alpha \Delta P_{t-1} + \beta (P_{t-1} - P_{t-1}^*) + \gamma \Delta P_t^* \tag{2}$$

Where P_t is the log of real house values at time t and Δ is the difference operator. The first term on the right in (2) is the serial correlation term. α is the serial correlation coefficient. The second term causes reversion to fundamental value. β (<0) is the rate of adjustment to fundamental value. The third term allows for immediate partial adjustment to fundamentals. Partial adjustment implies that $0<\gamma<1$.

Equation (2) can be rewritten in difference equation form as

$$P_t - (1+\alpha+\beta)P_{t-1} + \alpha P_{t-2} = \gamma P_t^* - (\beta+\alpha)P_{t-1}^* . \tag{3}$$

Analysis of the difference equation

The dynamic behavior of (3) can be determined by analyzing the characteristic equation given by

$$b^2 - (1+\alpha+\beta)b + \alpha = 0 . \tag{4}$$

Figure 1 summarizes the analysis. In the figure the curve defined by

$$(1+\alpha+\beta)^2 = 4\alpha \quad (5)$$

divides the parameter space into a cycles region below the curve and a no cycle region above the curve.

The vertical line at α=1 divides the parameter space into an explosive region to the right of the line and a damped region to the left. When the autocorrelation coefficient is above 1 any deviation from steady state is magnified over time and the path of values diverges from fundamentals.

From Figure 1 it is clear that various types of dynamic behavior can be accommodated within this simple model. Loosely speaking, as the serial correlation coefficient, α, increases, the persistence of cycles increases. As the reversion coefficient, β, increases, the amplitude of the cycle increases.

Empirical Implementation

We wish to explore the causes of differences in the dynamic response of metro areas to shocks to the local economy. In the context of the model, these differences will appear as different estimates of the parameters α and β. Therefore we rewrite (2) as

$$\Delta P_{kt} = (\sum_i \alpha_i Y_{kit}) \Delta P_{k,t-1} + (\sum_i \beta_i Y_{kit}) (P_{k,t-1} - P^*_{k,t-1}) + \gamma \, \Delta P^*_{kt} \quad (6)$$

where the Y_i are independent variables, k indexes cities and i indexes the variables.

An important issue is the choice of the Y_i. We explore several hypotheses in the empirical analysis which guide our choice of variables. First is the role of information dissemination. In real estate markets information costs are high. Transactions are infrequent and the product highly heterogeneous. As a result participants have difficulty assessing the current value of properties and may have to use sales distant in time or location for setting reservation prices. (Quan and Quigley 1991, Riddiough et. al. 1997) Markets with more transactions should have lower information costs and thus prices should adjust more quickly to their fundamental value. We include population as a measure of the number of transactions and thus information costs.

Another measure of the importance of information derives from models of search in housing markets (Wheaton, 1991, DiPasquale and Wheaton, 1996). In these search models, when a positive income shock occurs, existing homeowners are underhoused and must move or renovate to restore their housing consumption to the new equilibrium levels. By contrast, if population increases without an increase in income, only new residents need to move and transaction volume does not increase as much. When transactions volume increases, search costs decline and the reservation price for both buyers and sellers increases. Once the adjustment to new housing needs has occurred, transactions volume will fall back to their long-run level. In terms of our model, higher income growth should proxy for lower transactions costs, which should lead to faster mean reversion.

A second set of hypotheses relate to the cost of new housing. We identify two possible cost effects: within a given market and across markets. Across different markets high construction costs may serve as indicators of factors that reduce the short-run responsiveness of supply to demand shocks. This may be the case if high costs are correlated with unpriced supply restrictions. Regulation is an example of one such restriction. Stricter regulations on new development such as minimum lot size or regulatory-induced lags have two effects; they increase the cost of new housing (both in an absolute terms, and relative to existing housing) and they reduce the ability of builders to quickly respond to demand shocks. Mayer and Somerville (1997b) show that construction is less responsive to price shocks in markets with more local regulation. In the context of our model, higher construction costs should be correlated with slower mean reversion, and more serial correlation. The latter effect may be especially controversial--in this case new supply serves to reduce the degree of serial correlation because, in the absence of a futures market, it is the way that investors can arbitrage inefficient pricing. In markets where supply can respond quickly to price shocks, serial correlation-

-inefficient pricing-will be lower.

Within a given market, high construction costs indicate that short-run marginal costs exceed their long-run values. Previous research indicates that the short-run supply curve for housing within a market is significantly less elastic than long-run supply (Topel and Rosen, 1988, Mayer and Somerville 1997a). When construction costs are high compared to their long-run equilibrium level, this indicates that short-run prices are relatively high. To the extent that house prices are downwardly rigid, mean reversion may occur more quickly when construction costs are lower than normal, than when they are high. Thus we should expect faster mean reversion when construction costs are relatively low.

Finally, we look for evidence of euphoria, or backward-looking expectations as an indicator of the degree of serial correlation. Case and Shiller (1988, 1989) and Shiller (1990) posit that serial correlation in real estate markets is partially due to backwards-looking expectations of market participants. Case and Shiller (1988) have conducted surveys of recent buyers, showing that buyers in booming markets have greater expected house price appreciation than buyers in a control market. Buyers in the latter market indicate that they treat the purchase of a home more as an investment, and discuss housing market changes more frequently. By contrast, buyers in the control market spend less time discussing the housing market, and place more weight on the consumption value of a home, as opposed to its investment value. To the extent that these expectations are incorporated into observed transaction prices, markets in a boom should have more serial correlation than markets with slower income growth. We include income growth as an indicator of the state of the economic cycle. Long-run population growth is also included to measure the role of inertia/backward-looking expectations in serial correlation.

Data

Our data are a subset of the large panel data set described in Capozza, Kazarian, and Thomson (1997). The data for this study cover 62 metro areas for the 17 years from 1979-1995. Included among the variables are median house prices, population, personal income, construction costs, a land supply index, the consumer price index, mortgage rates, property tax rates, and income tax rates. The data are annual series with the exception of income tax rates which derive from the decennial census. The land supply index, a measure of the percentage of the land around the city that is available for development, varies across cities, but not over time. (See Rose 1989 and Capozza and Seguin 1996 for more detail on this variable.) Table 1 provides summary statistics on the data series.

Two variables require more discussion. The first is the median house price series. There is considerable debate over the merits of using median house price data and repeat sales data. This study uses the NAR median price series because of its long history and extensive coverage of metro areas. Repeat sales data are available at the regional level from the FHLMC but for a limited number of MSAs. The median and the repeat sales price series exhibit similar overall patterns, but there are timing differences, especially in the Northeast. The Pearson product-moment correlations of the price changes are .59, .73, .89, .88 and .92 for the Northeast, Southeast, Northcentral, Southwest, and West regions, respectively. The correlations of first differences suggest there will not be a large difference between empirical estimates from the two data series. Because our model estimates the long-run price level of housing in the first stage, we take advantage of the level differences within a city obtained with median prices. (Fixed effects are included for each city to control for differences across cities in the average quality of housing.) Repeat sales indexes only measure relative prices within a city over time, but not across different cities, and thus are not well-suited for an estimation procedure that utilizes the dollar value of housing.

Neither median nor repeat sales data are fully quality adjusted. The upward quality drift in the median prices is about 2% per year (Hendershott and Thibodeau, 1990) and occurs both because new houses of above average quality are added and because existing houses are renovated. In the typical metro area, much of the quality drift arises from renovations. Repeat sales data include only existing houses so that only the drift from renovations applies. Since typical repeat sales procedures attempt to exclude or adjust for houses that increase in size, the quality drift is mitigated. Many existing houses are renovated soon after purchase. For our purposes, a constant rate of upward drift will not affect the results since we include dummy variables for each year of the sample. A more important issue is systematic changes in the quality of the median house over an economic cycle. If the quality of the median house is systematically different near peaks than it is near troughs, the median price series will over or under estimate cyclical movements. However, as long as this bias is constant across cities, it will not impact our estimates of the factors that affect the cyclicality of prices.

The user cost variable is a derived variable. It is an attempt to capture the after tax cost of home ownership. Our calculation adjusts ownership costs for taxes and appreciation rates:[1]

User cost of capital = (Mortage rate + Property tax rate)(1 - Income tax rate) - Inflation rate. (7)

The definitions and sources of the remaining variables appears in Appendix A. The metropolitan areas included in the study are listed in Appendix B.

Empirical Estimates

To obtain empirical estimates for the above model, we begin by specifying the long-run equilibrium determinants of house price levels in a metro area using the annual panel data described in the previous section. Following Capozza and Helsley (1989, 1990) and Capozza and Sick (1992), equilibrium house prices are modeled as a function of the size of a metro area, the construction cost of converting land from agricultural use and building a new structure, an expected growth premium, and the user cost of

[1]See Capozza, Green and Hendershott (1997) for a derivation.

owner-occupied housing (the real after-tax discount rate).[2] The equation is estimated in two versions, first using OLS and second using a panel data estimator that controls for both year and metro area fixed effects. These fixed effects will pick-up any systematic differences in the average quality of housing across cities or over time. All variables are measured in logs.

The estimates from the above equation is given in Table 2. All variables have the expected sign and magnitude. In particular, real median house prices are positively related to total population, real median income, an index of real construction costs, and the 5-year growth rate in population (proxying for the long-run expected growth rate of population), and are negatively related to the user cost of housing and the land supply index.[3] The coefficients suggest reasonable elasticities. For example, the coefficient on real construction cost is 1.1 in model 1 and 0.96 in model 2 when fixed effects are included in the specification. Neither value is statistically different from the theoretical prediction of 1.03 at the 5 percent level. (The mean index value is .97; therefore a .01 unit increase in the cost index leads to a 1.03 (=1/0.97) percent increase in prices.) The coefficients on real income suggest that a one percent rise in a metro area's income leads to a 0.45-0.56 percent increase in median house prices, either because the prices of more desirable locations are bid up, or because consumers improve their existing units. The amount of developable land around a city, measured by the land supply index, has a negative and significant effect on the price level, as would be expected.

The price elasticity with respect to city size (population) in model 1 is about 0.07, smaller than would be obtained from a standard monocentric city urban model. However, the existence of fringe cities should lower the expected

[2]The equation does not explicitly control for differences across cities in the amount of systematic risk. See Gyrouko and Nelling (1996), who find no evidence of systematic risk in metro area real estate data.

[3]Blanchard and Katz (1992) show that the growth rate of population is persistent over time using state-level data over several decades.

size of the population coefficient relative to a standard urban model. Long-run growth has a large impact on price levels; a one percent increase in the population growth rate over the last 5 years leads to 5.9 percent higher house prices. In model 2, the coefficients on population level and growth are much less stable when fixed effects are included. This is likely because changes in the level and growth rate of population occur only slowly through time, and these effects are thus correlated with the fixed effect for each city. Somewhat more surprising, the user cost coefficient of -0.04 and -0.10 are statistically different from zero, but still well below the value of 1.0 predicted by theory.

In the empirical work that follows, we use model 2. F-tests of the significance of the time and metro area effects reject that these fixed effects equal zero at the 0.001 confidence level. The second stage analysis uses the estimates of P^* from the first stage equation to "anchor" the estimates of price changes. In particular, we estimate the following empirical equation, derived from (2) earlier:

$$\Delta P_t = \alpha \Delta P_{t-1} + \beta (P_{t-1} - P^*_{t-1}) + \gamma \Delta P^*_t, \tag{8}$$

where α represents the degree of serial correlation, β is the extent of mean reversion, and γ is the contemporaneous adjustment of prices to current shocks. Were real estate markets perfectly efficient, and if house prices adjusted instantaneously to local economic shocks, γ would equal 1 and α would equal 0. (If γ=1 and α=0, then theory has no prediction about the estimated value of β, because markets would be fully efficient and actual house prices would never deviate from their long-run fundamentals.) However, abundant academic research has shown that α is positive and economically and statistically significant. For example, Case and Shiller (1989) estimate that annual serial correlation in their sample of 4 cities ranges from 0.25 to 0.5.[4] (Also see Meese and Wallace, 1994.) Because

[4]Case and Shiller also note that the construction of repeat sales indexes induces spurious serial correlation in estimators derived from a single sample of

house prices do not diverge from their fundamental values in the long-run (Meese and Wallace, 1994; Rosenthal, 1995), $\alpha > 0$ implies $\gamma > 0$.

Estimates from this second stage equation are given in the Model 1 of Table 3. To control for possible omitted local factors that might cause differential appreciation rates, we initially included fixed effects for all MSAs. The subsequent regressions do not include these fixed effects in the second stage because an F-test of the significance of these factors does not allow for rejection at conventional confidence levels and the empirical work is little changed by their exclusion.

The empirical results in Table 3 are consistent with the previous real estate literature, but suggest significant inefficiency in real estate relative to other asset markets. The coefficient on γ, for example, suggests that current house prices adjust to only 18 percent of the value of a shock to predicted (or fundamental) house price levels in a given year. In addition, house prices also exhibit serial correlation, with a coefficient of 0.48. This estimate is consistent with that in Case and Shiller, for example. Furthermore, our estimates show that housing prices take a long time to converge to their long-run values. Actual prices only make-up 24 percent of this difference every year. In fact, the coefficients on γ and β are similar (hypothesis tests cannot reject that they are equal), suggesting a common rate of convergence to current shocks or past deviations from fundamental values.

Serial Correlation, Mean Reversion and Cycles

Evidence that real estate markets do not immediately adjust to changes in fundamentals and exhibit serial correlation has often been cited as showing that real estate price cycles are caused by inefficiencies in real estate markets. In one sense, this interpretation is correct. Local economies exhibit the same cyclical behavior as real estate prices. Inefficiencies in real estate markets

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houses. Such a bias does not affect our sample because we use median sales prices. Even with repeat sales indexes, however, spurious serial correlation would only bias the intercept in the third stage, not the coefficients on other explanatory variables.

lead to prices that do not immediately incorporate all market information and thus exhibit smooth behavior. However, other commentators have gone further, arguing that these inefficiencies cause house prices to significantly "overshoot" their fundamental values, leading to large crashes as prices return to their long-run values. Mathematically, the existence of large serial correlation coefficients does not necessarily imply that prices "overshoot" their fundamental values. As is clear from the earlier discussion, the behavior of house prices in equation (8) above is determined by a second order difference equation that is described by the characteristic equation in (4) and (5).

In Figure 1, we show the possible behavior of house prices depending on the values of the autocorrelation (α) and mean reversion (β) coefficients. For serial correlation, the results in Figure 1 show that conventional intuition is correct--holding the coefficient on mean reversion constant, higher values of serial correlation lead to a greater chance of cycles with "overshooting."

In the case of mean reversion, the results are more complicated. Consider a market that faces a positive shock to house prices due to higher real income or lower construction costs. Without serial correlation, market prices would converge to their fundamental values at a constant rate of β percent of the shock per year. When combined with serial correlation, the impact of mean reversion reverses itself. Greater cycles are observed with higher values of β (i.e., when prices converge more quickly to their fundamental values). The intuition is as follows. Serial correlation and mean reversion work in opposite directions. Consider the same positive shock to house prices. Prices in the first period rise by less than the full amount of the shock ($0<\gamma<1$). With positive serial correlation, prices will continue to rise in the next period for two reasons: positive serial correlation and mean reversion. With large enough values of mean reversion in the first period, the secondary "accelerator" effect of serial correlation could be enough to push house prices above their fundamental value. In subsequent periods, so long as $0 < \alpha < 1$, prices will begin to return to their fundamental values as the mean reversion component begins to dominate. Eventually house prices converge to their long-run values. For high enough values of mean reversion, however, house prices will initially "overshoot" their fundamental values and eventually converge to their fundamental values in a cyclical manner. This occurs because a large mean reversion coefficient implies that house prices will quickly "jump" towards their fundamental values. This jump causes additional serial correlation in the next period, leading to "overshooting."

Solving for the mean reversion and serial correlation coefficients suggests two issues of concern; the speed of convergence and the degree of overshooting. Absent serial correlation, higher values ofβ imply faster convergence to fundamental values. With serial correlation, higher values of Β still imply faster convergence, but convergence is not constant and market prices will further overshoot their fundamental levels. Given the coefficients from Table 3, we can solve for the cyclical behavior of the typical market in our sample. In particular, the average market is in the cyclical range (α=0.48, β=0.24), suggesting that prices will moderately overshoot their fundamental values.

The above estimates assume that the degree of serial correlation and mean reversion is constant across markets. This assumption violates the evidence in Case and Shiller, who find the degree of serial correlation varies across markets. While such variation might be a result of random fluctuations, it is also possible that systematic factors across markets may explain the variation in house price dynamics. The Abraham and Hendershott (1996) evidence suggests that cities on the coasts (Boston, NY, LA) have had much more significant real estate cycles than cities in the Midwest (Chicago, Milwaukee, Cleveland, Detroit).

In the third stage, we estimate possible determinants of the degree of serial correlation and mean reversion using variables derived from hypotheses described earlier, including city size (information dissemination), population growth (information dissemination), income growth (search costs, behavioral models), and construction costs (supply elasticities). These variables are interacted with the serial correlation and mean reversion variables, as in equation 6.

These estimates, presented in models 2 and 3 in Table 3, suggest significant evidence in favor of all three of the hypotheses. The most striking results are for the determinants of serial correlation. High construction costs and faster growth are associated with greater autocorrelation.

Differences across MSAs in construction costs lead to economically and statistically significant differences in serial correlation. For example, an increase in real construction costs of 10 percent would increase serial correlation by 12 percentage points--one-quarter of the overall serial correlation coefficient. To the extent that high construction costs are related to inelastic supply, the costs may be indicative of factors that do not allow the supply of new houses to adjust quickly to demand shocks. Regulation or geography might be two examples of such factors. Many types of land use regulation raise development costs and make it more difficult for developers to respond to market signals. Mayer and Somerville (1997b), for example, show that higher levels of regulation lead to fewer permits and lower supply elasticities. Reduced land availability, either because of historic development or small farms at the periphery of a city, may make land assembly more difficult and expensive.

In model 3, we explore the extent to which geography (the land supply index) is related to the construction cost result reported earlier. The results of model 3 show that the construction cost interaction with serial correlation is actually enhanced by the inclusion of the land supply interaction. However, the coefficient on the land supply interaction is the opposite of that predicted by theory and marginally statistically significant. These results suggest that regulation or short-run factors that raise construction costs above their long-run level are likely responsible for differences in serial correlation across markets.

Variables representing city growth in income and population also appear to have important accelerator effects on house prices. Higher income and population growth lead to greater serial correlation, an effect that is statistically significant in both models. A one-standard deviation shock to income of 2 percent, leads to a 7 percentage point increase in serial correlation (15 percent of the overall effect). The same 2 percent increase in the 5-year growth rate of population leads to an 11 percent increase in serial correlation (23 percent). Both of these results suggest that house prices exhibit much more serial correlation, and thus a greater likelihood of overshooting their fundamental values, in cities in the midst of an economic boom.

While the results for serial correlation are strong, the impact of various factors in explaining the degree of mean reversion are consistent with theory, but weaker in terms of statistical significance. None of the interaction coefficients are statistically significant at the 5 percent level, although two are significant at the 10 percent level.

City size is positively related to the degree of mean reversion, an effect that would be predicted from search models with imperfect information. Information about demand shocks is easier to discern in thicker markets in which comparable units sell more often. Thus prices should adjust more quickly to their fundamental levels because homeowners can more easily determine a price for a house that incorporates latest market information. The estimates show that prices revert to their mean 4 percentage points faster in a MSA that is twice as large as a comparison MSA.

Also consistent with search models, higher income growth leads to greater mean reversion. As with population size, the economic impact of differences in income growth is moderate. A 2 percentage point increase in the growth rate of income leads to a 2.5 percent increase in mean reversion (10 percent of the total effect).

Conclusion

Our results show that variation in the cyclical behavior of house prices across metropolitan areas is due to more than just variation in local economies. House prices react differently to economic shocks depending on such factors as growth rates, size, and construction costs. The results are much stronger--statistically and economically--in explaining serial correlation than mean reversion. While the average city in the sample has an autocorrelation coefficient of 0.48, a city with a zero growth rate of population and real income and relatively low construction costs (index=0.90) would have an autocorrelation coefficient of just 0.225. A city with 4 percent growth in population and real income, and high construction costs (index=1.04) would have a coefficient of 0.75. Similar types of variation in city size (5 versus 10 million people) and real growth rates of income (0 versus 4 percent) would lead to differences in mean reversion of 18 to 30 percent, with the latter occurring in large, high income growth cities.

High income growth leads to both a high degree of serial correlation and mean reversion. This combination gives the largest cyclical behavior of prices in simulations. In cities with strong economic growth leading to an initially large growth in fundamentals, house prices will continue to rise well beyond their equilibrium values after growth has slowed, eventually causing significant overshooting and a crash in prices. This evidence explains the extreme behavior of house prices in markets such as Los Angeles and Boston in the 1980s, which had large increases in real incomes and high construction costs over this period.

From a theoretical perspective, in which forward-looking prices should immediately incorporate all available information about future changes in house prices, these results are somewhat troubling. The findings can be broken-up into three categories. The findings relating to search and information--that is, the impact of city size and income growth on mean reversion--do not challenge the notion of market efficiency. Differences in information flows and trading frequency should affect the dynamic behavior of equilibrium prices for a heterogenous good such as housing. However, the impact of factors affecting serial correlation are more difficult to explain. Consider first the impact of growth rates of income and population on the momentum in price changes (autocorrelation). An efficient market should arbitrage the expected cyclical behavior of prices, dampening cycles and reducing autocorrelation. In this sense, the positive correlation between construction cost and autocorrelation is instructive. In the absence of complete financial markets for real estate, new construction is a means through which investors can arbitrage inefficient pricing (i.e., home builders can build more houses when prices exceed their equilibrium level, forcing prices lower). Our results show that markets with high construction costs have more autocorrelation (less efficient pricing).

Like others before us, this paper does not explain why such arbitrage does not occur more quickly. High transactions cost clearly limit the ability of investors to buy real estate when its expected future returns are high. However, individual home buyers and sellers should still incorporate this information in their transactions. Future research should explore micro evidence on the behavior of individual home buyers, particularly the role of liquidity, information, and psychology. Lamont and Stein (1996) show that house prices in cities with high levels of leverage are more sensitive to income shocks than house prices in cities with less leverage. At an individual level, Genesove and Mayer (1997) show that leverage has a large impact on seller reservation prices in a downturn, affecting both the probability of sale, and the subsequent sales prices. Others have shown that liquidity affects refinancing behavior and mobility. While Case and Shiller (1988) use surveys to show that market conditions affect the reported expectations of recent home buyers, few papers have explored the role of information and psychology on expectations formations and transactions prices.

From a policy perspective, this paper suggests ways to reduce the volatility of house prices. As Shiller (1993) has noted, the development of a futures market could allow investors to buy or sell real estate with much lower transactions cost, ensuring more efficient pricing. In the absence of complete markets, governments could reduce barriers to new construction. In the past, many policymakers have viewed developers as part of the problem--feeding the frenzy in a boom. However, new construction is just the market's response to high prices. The findings here demonstrate that construction has a role in dampening cycles. Developments in information technology will provide better information to buyers and sellers, allowing them to negotiate more efficient agreements. Finally, the increasing role of public capital markets in real estate may reduce the volatility of prices by making capital availability less dependent on a local banking sector.

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Appendix A
Data Sources and Definitions

Median sales price of existing homes & National Association of Realtors Real Estate Outlook; annual data, except that latest year is arithmetic mean of quarterly prices

Metro area population & Annual mid-year estimate, Bureau of the Census; supplied by the Bureau of Economic Analysis, May, 1995

Total employment, metro area & Bureau of Economic Analysis May, 1995

Construction employment, metro area & Bureau of Economic Analysis May, 1995

Nominal personal income per capita & Bureau of Economic Analysis May, 1995

Local area construction cost indexes & R.S. Means Handbook

State average property tax rates (used in calculating homeowner's % cost of capital) & American Council on Intergovernmental Relations Significant Features of Fiscal Federalism, 1994. The property tax series is published only occasionally

National average home mortgage interest rate (used in calculating homeowner's % cost of capital) & Economic Report of the President for the current year, or Statistical Abstract of the United States

The annualized Consumer Price Index for all urban consumers (used in % deflating income and house prices) & Electronic edition of the Economic Bulletin Board, October, 1995

Appendix B
Metropolitan Areas Included in the Study

Code name & Census name

Northern Atlantic Region
Boston & Boston-Worcester-Lawrence-Lowell-Brocktn, MA-NH (NECMA)
Hartford & Hartford, CT (NECMA)
Providence & Providence-Warwick-Pawtucket, RI (NECMA)
New York & New York-Northern New Jersey-Long Island, NY-NJ-CT-PA (CMSA)

Middle Atlantic Region
Baltimore & Baltimore, MD (PMSA)
Philadelphia & Philadelphia, PA-NJ (PMSA) Washington DC & Washington, DC-MD-VA-WV (PMSA)

Southeastern Region
Birmingham & Birmingham (MSA)
Fort Lauderdale & Fort Lauderdale, FL (PMSA) Knoxville & Knoxville, TN (MSA)
Louisville & Louisville, KY-IN MSA
Memphis & Memphis, TN-AR-MS MSA
Nashville & Nashville, TN (MSA)
New Orleans & New Orleans, LA (MSA)
Tampa & Tampa-St. Petersburg-Clearwater, FL (MSA)
West Palm Beach & West Palm Beach-Boca Raton, FL (MSA)

Great Lakes Region
Akron & Akron, OH (PMSA)
Albany & Albany-Schenectady-Troy, NY (MSA) Chicago & Chicago-Gary-Kenosha, IL-IN-WI (CMSA) Columbus & Columbus, OH (MSA)
Detroit & Detroit-Ann Arbor-Flint, MI (CMSA)
Grand Rapids & Grand Rapids-Muskegon-Holland, MI (MSA) Indianapolis & Indianapolis, IN (MSA)
Milwaukee & Milwaukee-Waukesha, WI (PMSA) Minneapolis-St. Paul & Minneapolis-St. Paul, MN-WI (MSA) Rochester & Rochester, NY (MSA)
Saint Louis & Saint Louis, MO-IL (MSA) Syracuse & Syracuse, NY (MSA)

Great Plains Region
Des Moines & Des Moines, IA (MSA)

Kansas City & Kansas City, MO-KS (MSA) Omaha & Omaha, NE-IA (MSA)

Southwestern Region
Albuquerque & Albuquerque, NM (MSA)
El Paso & El Paso,TX (MSA)
Houston & Houston-Galveston-Brazoria, TX (CMSA) Oklahoma City & Oklahoma City, OK (MSA)
Salt Lake & Salt Lake City-Ogden, UT (MSA) San Antonio & San Antonio, TX (MSA)
Tulsa & Tulsa, OK (MSA)
Dallas & Dallas-Fort Worth, TX (CMSA)

Southern California Region
Los Angeles & Los Angeles-Long Beach, CA (PMSA)
Orange County & Anaheim-Santa Ana-Garden Grove (Orange County, CA)
Riverside-San Bernadino & Riverside-San Bernardino, CA (PMSA)
San Diego & San Diego, CA (MSA)

Northern Pacific Region
San Francisco & San Francisco-Oakland, CA (CMSA)

Table 1. Summary Statistics

	Mean	Standard Deviation	Minimum	Maximum
Real Price	72,000	27,000	41,000	210,000
Change in Real Price	0%	5%	-14%	29%
Population	2,300,000	3,100,000	370,000	20,000,000
5 Year Change in Population	7%	7%	-6%	31%
Real Personal Income	14,000	2,200	7,700	22,000
Change in Real Personal Income	1%	2%	-7%	12%
Real Construction Cost Index	0.97	0.01	0.78	1.5
User Cost	7%	n/m	0%	11%
Land Supply Index	0.89	0.13	0.54	1

Table 2. Steady State Price Level Regression. Dependent variable is the log of real price. OLS estimates of equation 1 in the text. Model 2 is estimated with fixed effects.

	Model 1		Model 2	
	Coefficient	T-Statistic	Coefficient	T-Statistic
Log of Population	0.07	7.6	-0.12	-2.2
Log of Real Income	0.45	9.2	0.56	6.4
Real Construction Cost	1.1	13.8	0.96	9.6
% Change in Population	5.9	12.3	0.60	1.3
Log of User Cost	-0.4	-2.7	-0.10	-3.0
Land Supply Index	-0.37	-7.0		
Fixed Effects (City, Year)	No		Yes	
R^2	0.61		0.92	

Table 3. Second Stage Price Change Regressions. Dependent variable is the percent change in real housing price. Ordinary least squares estimates of equation 6 in the text.

	Model 1		Model 2		Model 3	
	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
Change in the First Stage Fitted	0.18	2.6	0.20	3.0	0.20	3.0
Lagged Change in Price	0.48	17.2	-0.81	-3.2	-1.35	-3.2
Change in Population times Lagged Price Change			5.28	2.5	5.55	2.6
Change in Income times Lagged Price Change			3.94	3.2	3.99	3.2
Construction Cost times Lagged Price Change			1.15	4.7	1.36	4.9
Land Supply Index times Lagged Price Change					0.37	1.6
Deviation from Steady State	-0.24	-14.7	-0.21	-1.4	-0.22	-1.4
Log Population times Deviation from Steady State			-0.04	-1.7	-0.03	-1.5
Change in Income times Deviation from Steady State			-1.22	-1.8	-1.28	-1.8
Construction Cost times Deviation from Steady State			0.26	1.3	0.23	1.2
R^2	0.47		0.49		0.49	

Figure 2. The dynamic behavior of the difference equation. This graph illustrates the parameter values which generate housing cycles when fundamentals are shocked. Values of the autocorrelation coefficient greater than 1 result in explosive behavior. Parameter values that lie below the curve result in cycles.

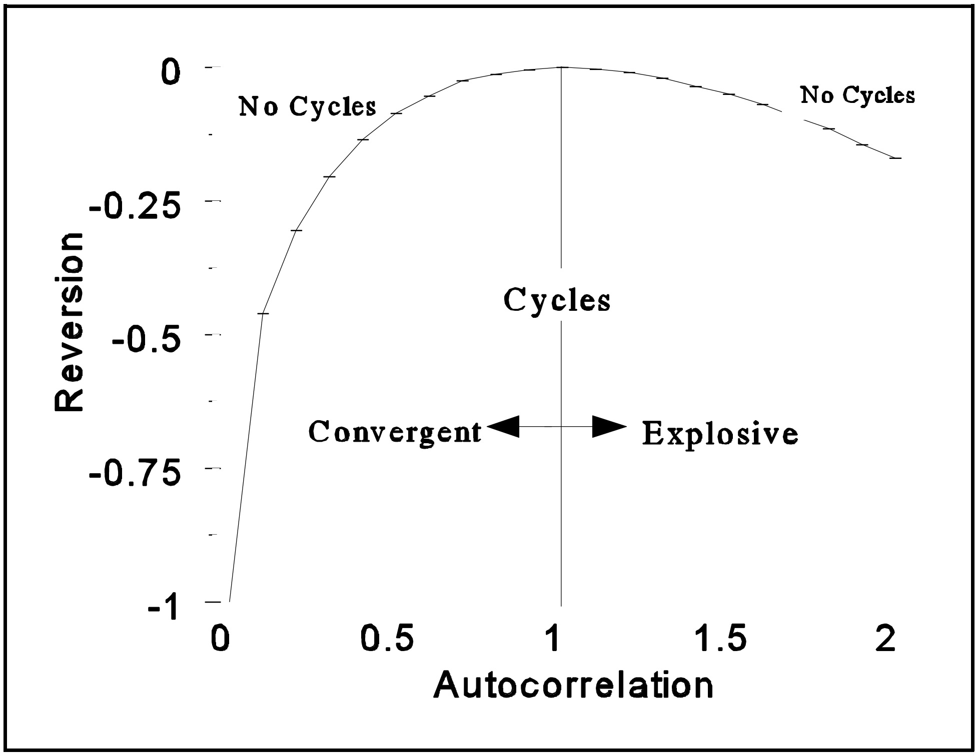

Figure 6. The Sample Range. This figure plots the impact of the range of the variables on the estimates of the autocorrelation and reversion parameters. Note that most of the estimates lie in the cyclical region.