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ECONOMIC FUNDAMENTALS IN LOCAL HOUSING MARKETS: EVIDENCE FROM U.S. METROPOLITAN REGIONS

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ABSTRACT. This paper investigates the effects of national and regional economic conditions on outcomes in the single-family housing market: housing prices, vacancies, and residential construction activity. Our three-equation model confirms the importance of changes in regional economic conditions, income, and employment on local housing markets. The results also provide the first detailed evidence on the importance of vacancies in the owner-occupied housing market on housing prices and supplier activities. The results also document the importance of variations in materials, labor and capital costs, and regulation in affecting new supply. Simulation exercises, using standard impulse response models, document the lags in market responses to exogenous shocks and the variations arising from differences in local parameters. The results also suggest the importance of local regulation in affecting the pattern of market responses to regional income shocks.

1. INTRODUCTION

Housing markets are local, and housing market outcomes reflect local economic conditions. Housing prices are bid up as a result of better employment opportunities and higher incomes enjoyed by residents in an expanding metropolitan market. Changes in the distribution of income are reflected in the distribution of prices and housing amenities. Similarly, housing vacancy rates can be expected to decline when the local economy improves and as the demand for housing increases. Finally, residential construction and building activity are responsive to housing prices, vacancy rates, and the health of the local economy. As higher incomes increase the demand for housing, prices are bid up; new construction becomes more profitable, inducing supplier activity. Dwellings that would otherwise become vacant remain occupied, and some dwellings that would otherwise leave the housing stock are renovated for continued use.

This paper considers the inter-relationship among these three forms of economic behavior in the context of local housing markets. We model the

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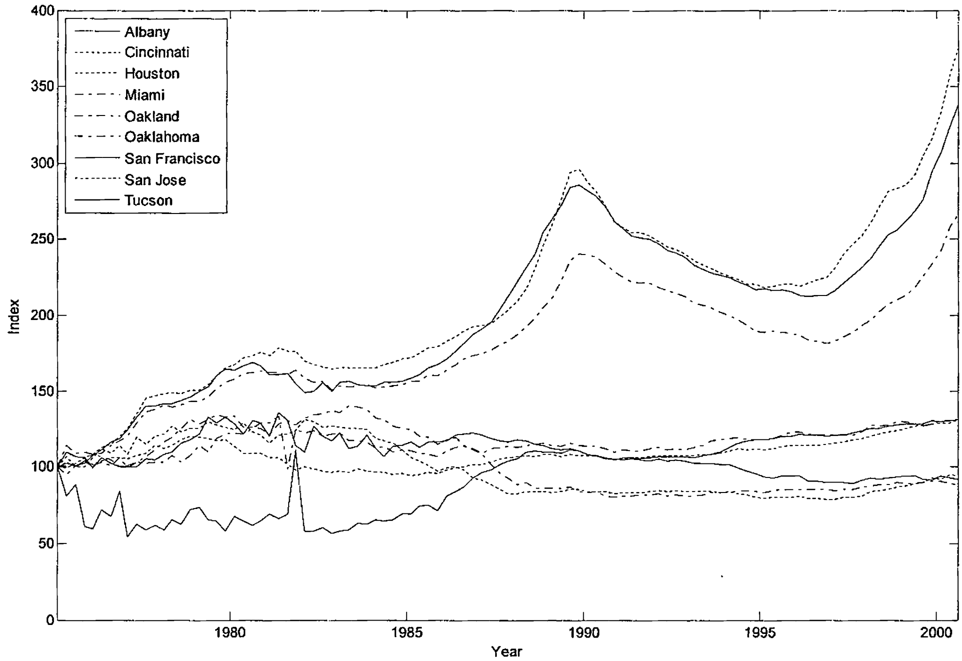

FIGURE 1: Course of Real Housing Prices in Nine Metropolitan Areas, 1975–2000.

relationship among the prices of owner-occupied housing, vacancy rates, and housing supplier activity in response to the exogenous factors, which affect the fortunes of the regional economy. We also recognize the importance of local land use and building regulations in affecting the operation of the owner-occupied housing market.

Our analysis uses U. S. metropolitan areas (MSAs) as units of observation, and we follow a panel of 74 MSAs over the 13-year period, 1987–1999. The panel includes all U.S. metropolitan areas for which annual data are available on the prices of owner–occupied housing, on the vacancy rates in single-family housing, and on supplier activity (i.e., the number of permits issued for construction of new single-family housing).

Figure 1 illustrates the course of housing prices during 1975–2000 for nine of the MSAs in the sample we analyze below.[1] Note the enormous variation in the course of house prices. For the three California housing markets depicted, real prices more than tripled between 1975 and 1999. For the least

[1]The figure relies upon the price series maintained by the U.S. Office of Federal Housing Enterprise Oversight, as described in Section V.

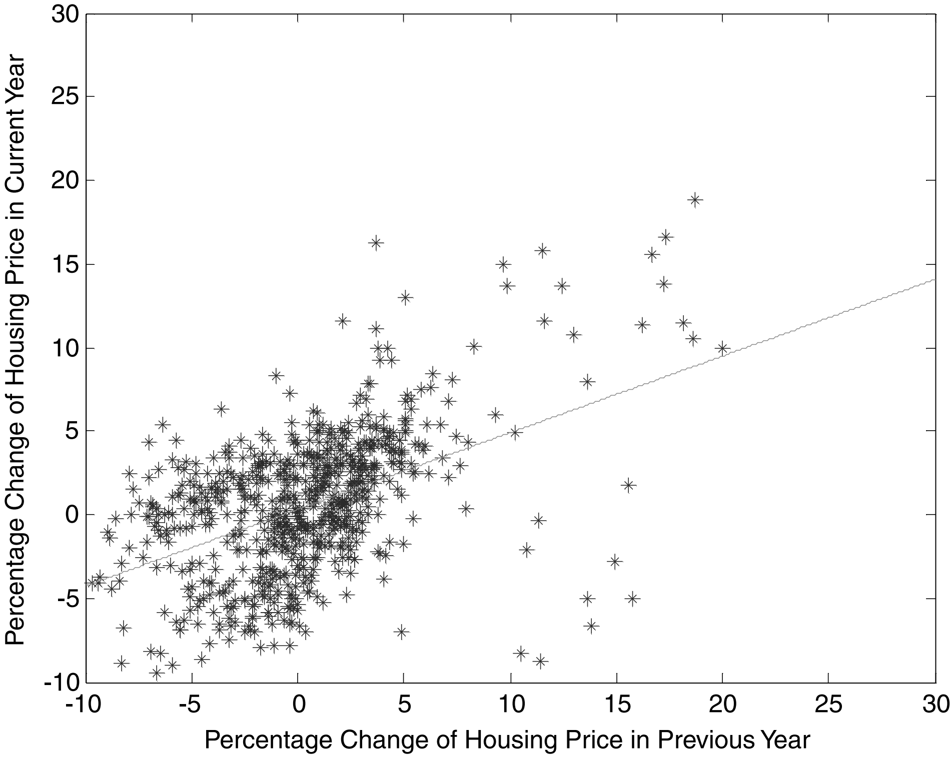

FIGURE 2: Current Real House Price Changes vs. Lagged House Price Changes, 1987–1999* (74 metropolitan areas).

*The regression relationship (t-ratios in parentheses) between the percentage change in real housing prices in the current year, y_t, and the percentage change in the previous year, y_{t-1}, is

$$\underset{(2.029)}{y_t = 0.2948} + \underset{(15.02)}{0.4585 y_{t-1}} \qquad R^2 = 0.234.$$

volatile markets in the sample (Houston, Albany, and Oklahoma City), nominal housing prices doubled during the past quarter century. As noted in the figure, real housing prices in these latter markets were stagnant. What causes this enormous variation?

Figures 2, 3, and 4 illustrate some key relationships explored in this paper. Figure 2 investigates the predictability of housing price changes using our panel of MSAs covering 1987–1999. It presents the current annual real price changes in each of the 74 markets as a function of their lagged values. There is clearly a strong positive relationship, suggesting that lags and slow adjustment to market conditions are crucial to understanding the course of prices.

Figure 3 indicates the bivariate relationship between annual changes in vacancy rates for single-family dwellings and changes in their prices, while

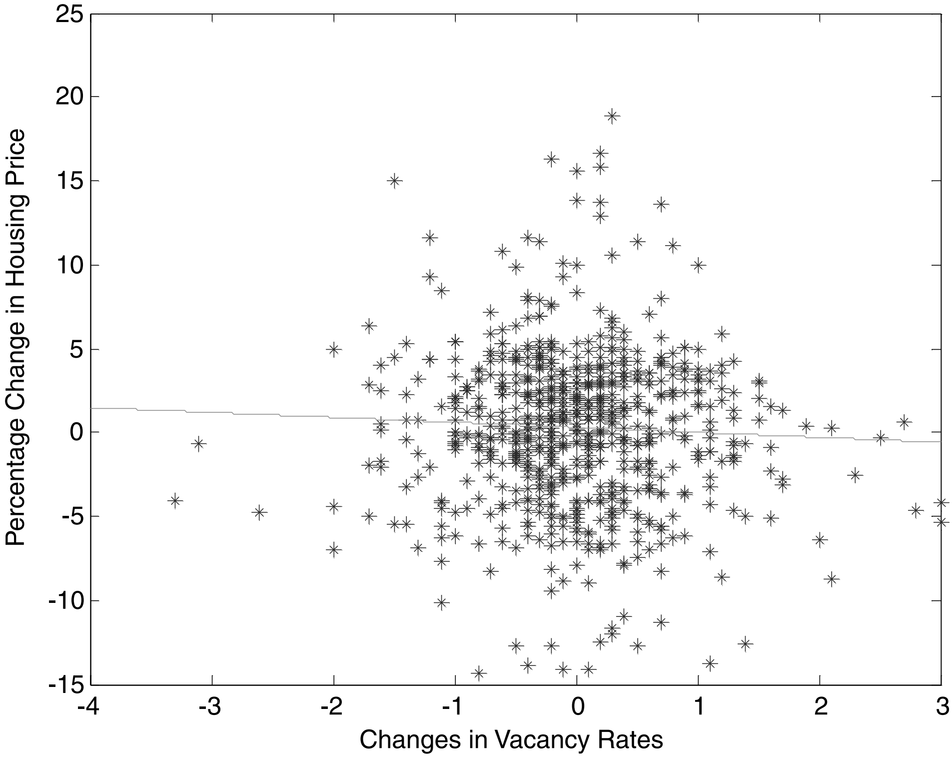

FIGURE 3: Changes in Real House Prices vs. Changes in Vacancy Rates, 1987–1999* (74 metropolitan areas).

*The regression relationship (t-ratios in parentheses) between the percentage change in real housing prices, y_t, and changes in vacancy rate, x_t, is

$$\underset{(1.827)}{y_t = 0.3029} - \underset{(1.314)}{0.2975x_t} \qquad R^2 = 0.0023.$$

Figure 4 illustrates the relationship between annual changes in house prices and the number of building permits issued for new construction of single-family housing in these same metropolitan areas.[2] These two figures provide little evidence of the systematic relationships postulated by economic theory. In particular, there is very weak evidence in the simple diagram that housing prices decrease as vacancy rates increase. There is some evidence that increases in supplier activity, measured by building permits, affect housing prices. But the relationship is very weak. Is there any strong empirical link between vacancies, new supply, and housing prices?

In this paper, we develop a model relating exogenous changes in regional employment and incomes, construction costs and macro economic conditions

[2]As noted below, data for both vacancy rates and building permits are maintained by the US Census Bureau.

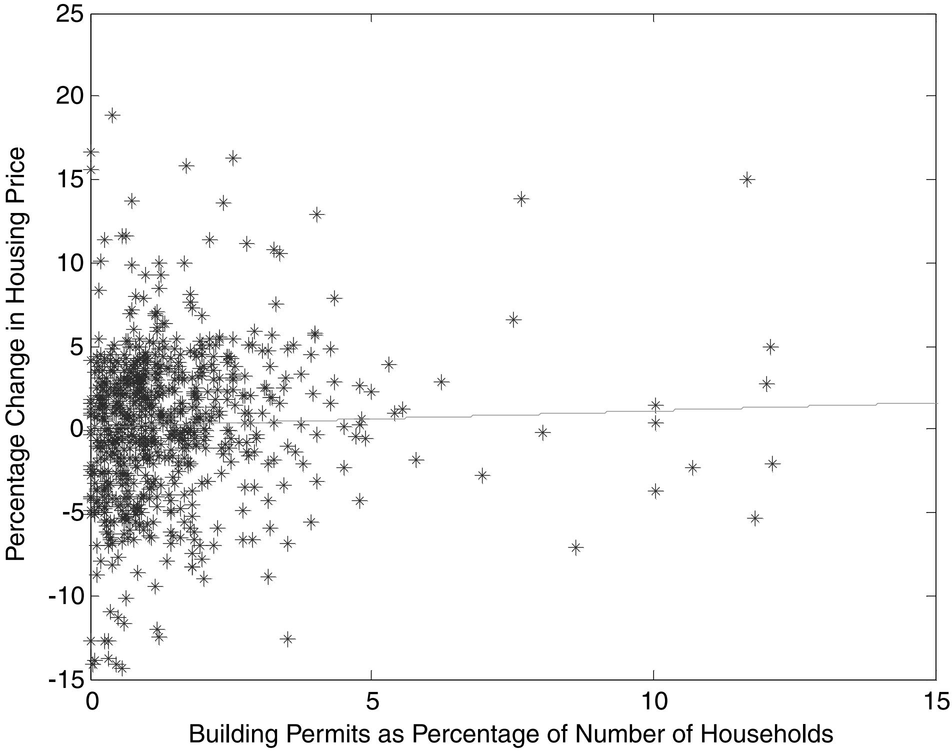

FIGURE 4: Changes in Real House Prices vs. Building Permits 1987–1999* (74 metropolitan areas).

*The regression relationship (t-ratios in parentheses) between the percentage change in real housing prices, y_t, and building permit, x_t, is

$$y_t = \underset{(0.677)}{0.1249} + \underset{(2.188)}{0.0978}x_t \qquad R^2 = 0.0064.$$

to these measures of the health of housing markets—prices, vacancies, and new construction. The model is estimated in several variants, and we simulate the responsiveness of the housing market to local economic conditions. The model indicates the strong interdependency between the state of the macro economy, the state of the regional economy, and outcomes in the housing market. The results also suggest the key role of local regulation in affecting housing outcomes.

In Section 2 below, we relate our work to previous attempts to develop regional models of the housing market. Section 3 presents an overview of the data and the methodology we use, as well as the relationships among the various measures of the housing market. Section 4 presents data. Section 5 presents our statistical results and the simulations based upon them. Section 6 is a brief conclusion.

2. ANTECEDENTS

A simple model of supply and demand at the regional level motivates the choice of variables to explain outcomes in the housing market over time. Housing demand is a function of prices and incomes and perhaps demographic variables as well. Housing supply is a function of profitability, which depends upon housing prices and input prices, including the costs of labor, materials, financing, and regulations inhibiting new construction. Vacancy rates in existing housing reflect the difference between aggregate supply and demand in the market in any period.

Several early papers (following Reid, 1962; Muth, 1960, 1968) analyzed variations in housing prices across metropolitan areas, focusing on the reduced form of relationship between the prices of owner-occupied housing and metropolitan characteristics. Using these models, it is easy to describe the development of house prices, but it is quite difficult to make inferences about structural parameters or about causation.[3]

In contrast, a few more recent studies have investigated structural relationships among housing market outcomes. Poterba (1984) analyzed the interaction between movements in prices and housing stocks, modeled as a two-equation system. The growth of housing prices is represented as a function of the difference between current prices and imputed rentals, while the growth of the housing stock is related to real housing prices (as a proxy for profitability) and to the size of the current stock. In this simple stock-flow model, there are no leads or lags. Vacancies in the housing stock are ignored.

DiPasquale and Wheaton (1994) specified a model for housing demand in which the price of owner-occupied housing within a given housing market is a function of the current stock of single-family housing relative to the number of households, their age-expected homeownership rate,[4] the cost of renting relative to owning in the market, and the average household income within the market. In a second equation, the authors modeled housing starts as a function of current prices, costs, and the stock of housing, as well as employment and time on the market for new units. Most of supplier behavior in this model is explained by exogenous changes in interest rates, employment levels, and time on the market. The authors interpret this latter variable as evidence of slow adjustment in housing markets.

Follain and Velz (1995) developed a structural model of housing markets at the metropolitan level, in part to reflect the importance of turnover (the inverse of time on the market) in housing markets. Their structural model consists of four equations predicting the turnover rate, housing size, housing prices, and household formation, respectively. Follain and Velz found that housing

[3]Tests of the efficient functioning of housing markets based on these reduced form models are in fact joint tests of the efficiency of the housing market together with the underlying structural models used to derive reduced form relationships (Follain and Velz, 1995).

[4]The age-expected homeownership rate is a simple transformation of the age distribution of adults in the housing market.

prices and turnover are negatively related; they attribute this to the reduced importance of down payment constraints since the mid 1980s. However, their estimates of some key structural parameters are quite large indeed (e.g., the estimated price elasticity of housing supply is about six).

In assessing this previous work on the determinants of housing price variations, several factors are worth noting. First, none of these empirical models considers that trends in house prices or new construction might be mitigated by changes in vacancy rates for owner-occupied housing. This is in contrast to extensive empirical analyses of the rental market (e.g., Rosen and Smith, 1983; Igarashi, 1992; Read, 1993; Hendershott et al., 2000; Gabriel and Nothaft, 1988, 2001), which emphasize the inverse relationship between rents and vacancy rates across markets. Second, equations explaining variations in housing supply are often unsatisfactory, in contrast to demand equations, which tend to fit the data reasonably well. The estimated supply elasticity often has a negative sign, an insignificant effect, or an implausibly large magnitude. Third, with one exception, these systems of structural equations applied to housing markets are tested on aggregate national time-series data despite the local nature of housing markets. This limitation no doubt reflects difficulties of data assembly at the metropolitan level.

3. OVERVIEW OF THE MODEL

Our model of regional housing markets is based upon a panel of U.S. metropolitan areas, including all markets for which annual data on housing prices, vacancies, and construction activity are available for owner-occupied housing. Of the 334 metropolitan housing markets (MSAs) in the United States, consistent measures of house prices are available for 120, beginning in 1975. Annual measures of the stock of owner-occupied housing, vacancy rates, and supplier activity (i.e., building permits) are available for only 75 MSAs and only for the period 1987–1999. Our analysis is based upon 962 observations reporting a panel of 74 MSAs observed annually during the period 1987–1999.[5]

Some of the key bivariate relationships in this panel of housing markets are reported in the Section I. Figures 5, 6, and 7 present additional descriptive information. Figure 5 suggests that there is a strong positive relationship between price appreciation in these markets and a measure of the restrictiveness of regulations covering new construction.[6] Figure 6 reports a positive, but rather weak, relationship between price appreciation and income growth, while Figure 7 reports the absence of any simple relationship between house price appreciation and employment growth. These puzzles and suggestive relationships motivate our systematic research.

[5]For one MSA (Scranton, PA) house prices are not available, but vacancy rates, supplier activity, and housing stock measures are.

[6]Glaeser et al. (2003) attribute substantial difference between prices and production costs of Manhattan condominiums to land-use regulations. See Quigley and Rosenthal (2005) for a review of empirical evidence.

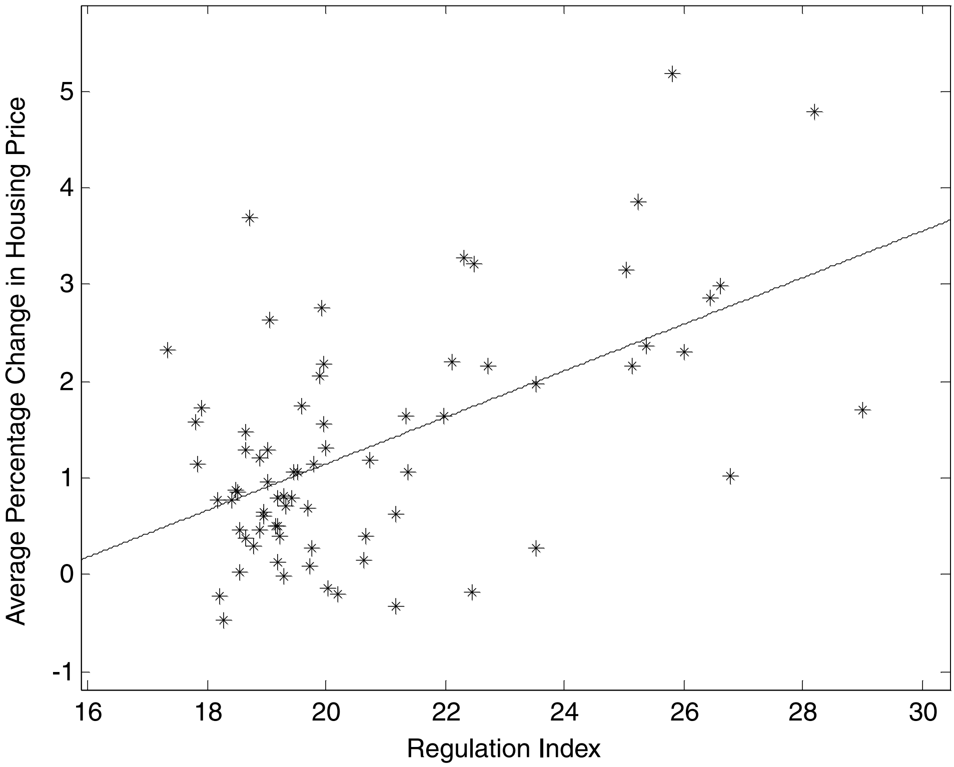

FIGURE 5: Average Real House Price Appreciation vs. Regulation Index*
(74 metropolitan areas).

*The regression relationship (t-ratios in parentheses) between the percentage change in average real housing prices, y_t, and the regulation index, x_t, is

$$y_t = -0.0092 + 0.0006x_t$$
$$\quad (0.799) \quad (5.688) \qquad R^2 = 0.310.$$

Our empirical model consists of three equations describing the movement of housing prices, housing supply, and vacancies in the market for owner-occupied housing. In this section, we describe the key features of the model, deferring issues related to data, measurement, and estimation technique to Section IV.

Housing Prices

Our analysis of housing prices is based upon an extension of the work of DiPasquale and Wheaton (1994), which considers the distinction between the number of households in the housing market and their individual demands for owner occupancy. We extend the model to include vacancies

$$H_t \cdot D_t = OC_t = S_t - V_t = S_{t-1} + N_t - V_t \tag{1}$$

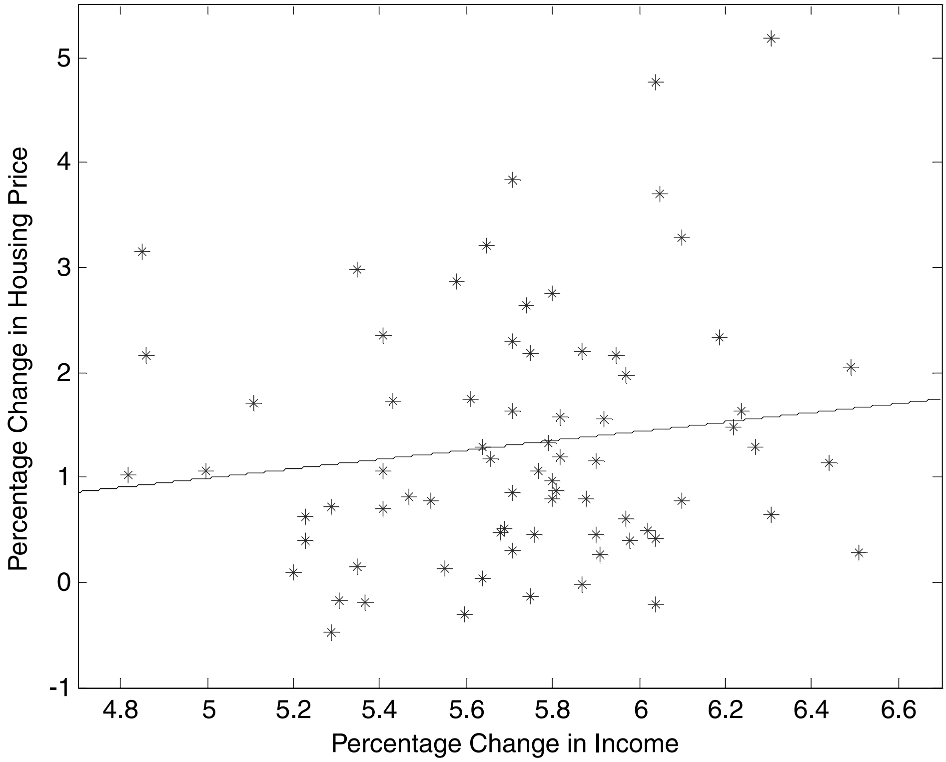

FIGURE 6: Average Real House Price Appreciation vs. Income Growth*
(74 metropolitan areas).

*The regression relationship (t-ratios in parentheses) between the percentage change in average real housing prices, y_t, and the percentage change in real income, x_t, is

$$\underset{(0.584)}{y_t = -1.2393} + \underset{(1.207)}{0.4461x_t} \qquad R^2 = 0.020.$$

where H_t is the total number of households in a metropolitan market at the time t, D_t is the proportionate demand for owner occupancy, OC_t is the number of occupied units of owner housing, S_t is the total stock of owner-occupied housing, V_t is the number of vacancies, and N_t is the number of newly constructed owner-occupied units.[7] The subscript i distinguishing metropolitan area is suppressed

[7]Our model concentrates on owner-occupied housing, considering rental housing only to the extent that relative prices by tenure type affect tenure choice and to the extent that the level of dividends (rents) affects asset prices (house values). Thus we assume that the stock of owner-occupied housing, S_t, may decline through depreciation but not through conversion to rental units. Of course, this is not literally true, but structural characteristics do inhibit conversions in tenure type. For example, as estimated in the 2001 American Housing Survey, 88 percent of single detached structures are owner-occupied, and 88 percent of apartment dwellings are renter-occupied. A more complete model would allow for the rental of single detached housing and the conversion of apartments to condominiums. But this would be a much more complicated model.

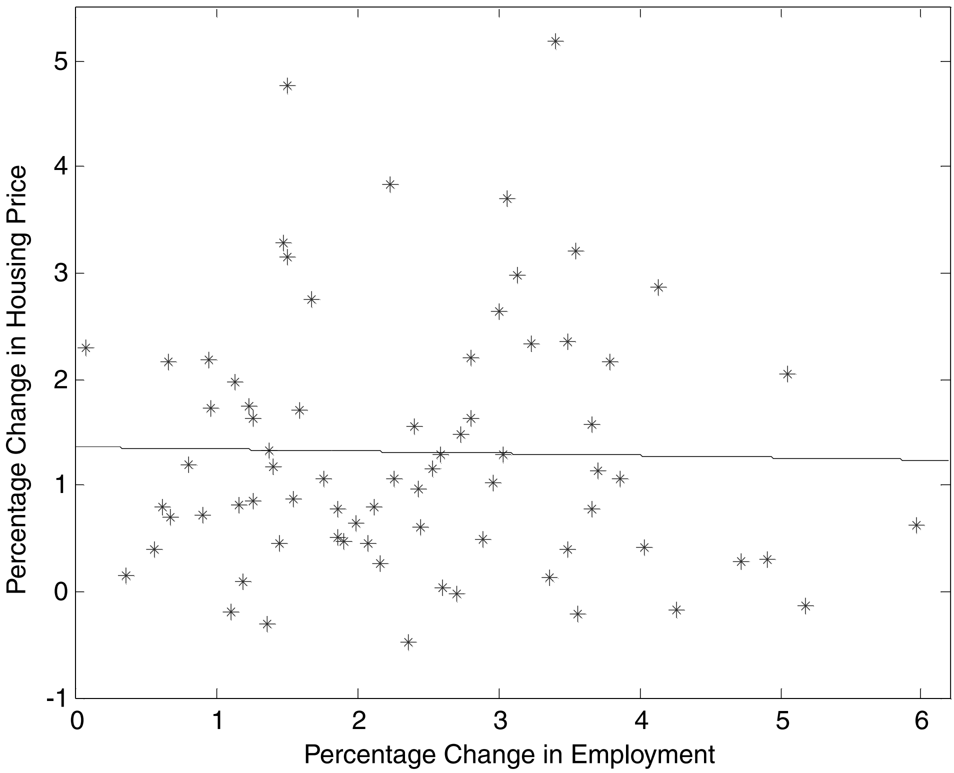

FIGURE 7: Average Real House Price Appreciation vs. Employment Growth*

*The regression relationship (t-ratios in parentheses) between the percentage change in average real housing prices, y_t, and the percentage change in employment, x_t, is

$$y_t = 5.7309 - 0.0206x_t$$
$$(4.586) \quad (0.188) \qquad R^2 = 0.0005.$$

for ease of presentation. Following DiPasquale and Wheaton (1994), individual demand for owner-occupied housing is

$$D_t = D\left(P_t^*, UC_t, R_t, X_t^D\right) \tag{2}$$

where P_t^* is the market-clearing price of owner-occupied housing, UC_t is its annual user cost, R_t is the cost of renting, and X_t^D represents other demand shifters (e.g., income, demographics).

As asset prices and annual user costs for owner-occupied housing increase, individual households are less likely to choose owner-occupancy; as the cost of renting increases, households are more likely to choose owner-occupancy. Changes in rents can affect house prices in two different ways. First, in the context of tenure choice, as the cost of renting increases, households are more likely to choose owner-occupancy, raising the price. Second, in the context of asset pricing, rent is a dividend from owning a house, and price will be a discounted sum of future rents. If rents are correlated over time, changes in current rents imply changes in future rents, which in turn affect housing prices. Since rents are more likely to exhibit positive serial correlation, a rise in current rent implies a rise in housing prices. When rents and prices are nonstationary, it is easy to show that the rent-price ratio can predict the future growth rate of rents.[8]

The probability of owner-occupancy times the number of households in the market equals the number of units of owner-occupied housing in the local market. Assuming log linearity in D_t using the approximation in Appendix A, solving for the market-clearing price of housing, and taking first differences yields

$$p_t^* = \alpha_1^* s_t + \alpha_2^* v_t + \alpha_3^* uc_t + \alpha_4^* r_t + \alpha_5^* h_t + \alpha_6^* x_t^p + \varepsilon_t^{p*} \tag{3}$$

where lower case letters represent logarithmic differences, Greek letters represent parameters, and x_t^p represents a set of demand shifters. If we further assume partial adjustment in asset prices of owner-occupied housing

$$\log P_t - \log P_{t-1} = \delta\left[\log P_t^* - \log P_{t-1}\right] \tag{4}$$

the pricing relationship can be expressed in observables

$$p_t = \alpha_1 s_t + \alpha_2 v_t + \alpha_3 uc_t + \alpha_4 r_t + \alpha_5 h_t + \alpha_6 x_t^p + \alpha_7 p_{t-1} + \varepsilon_t^P \tag{5}$$

where $\alpha_i = \delta\alpha_i^*$ for $i = 1, 2, \ldots, 6$, $\alpha_7 = \delta$, and $\varepsilon_t^P = \delta\varepsilon_t^{P^*}$. An increase in housing stock, s_t, is expected to reduce housing prices. Rent is expected to have a positive sign, as should income, employment, and the number of households. The user cost of housing is expected to have a negative effect. With partial adjustment, the lagged change in price will also have a positive effect on current prices.

New Housing Supply

In contrast to the analysis of housing demand and price formation, less is known about the behavior of housing supply. In part, this reflects limitations in available data and in conceptual models (Rosenthal, 1999). DiPasquale (1999) has summarized three empirical difficulties in the housing supply literature. First, estimated housing supply elasticities vary widely. Second, price does not seem to be a sufficient statistic, and other market indicators are quite important in explaining housing supply. Third, construction levels seem to respond quite sluggishly to construction costs and output prices. Furthermore, there are disagreements about the appropriate specification of models of housing supply. In early research, new housing supply, measured by either housing starts or by permits, is specified as a function of the *level* of price and the *level* of construction cost (Porterba, 1984; Topel and Rosen, 1988; DiPasquale and Wheaton, 1994). More recently, however, Mayer and Somervile (2000) developed an empirical model linking new housing supply to *changes* in prices and costs. They

[8]This is implied by standard present value models. See Shiller (1981). For empirical testing of the present value model of housing, see Hwang, Quigley, and Son (2006).

argue that the equilibrium level of housing price matches the stock of housing supplied with the total demand for housing space, which implies that new construction will be a function of changes in housing price, as well as changes in other variables, such as construction costs.

We follow Mayer and Somerville, modeling new housing supply as a function of changes in prices and input costs, as well as macroeconomic conditions. Our model is

$$s_t = \beta_1 p_t + \beta_2 v_t + \beta_3 c_t + \beta_4 f_t + \beta_5 REG_t + \beta_6 x_t^s + \beta_7 p_{t-1} \tag{6}$$

where s_t is new housing supply, v_t represents vacancies, c_t is input costs for labor and materials, f_t is financing costs, REG_t is the restrictiveness of local regulation, and x_t^s represents other supply shifters. We measure new supply as the annual difference in the stock of housing; the stock is constructed by adding building permits to the stock in the previous year.[9] Again, lower case letters indicate logarithmic differences. Note that this specification of the supply equation includes two endogenous variables, changes in housing prices and changes in vacancies. We expect that increases in housing prices will lead to an increase in supplier activity. Increases in input costs (labor, materials or financial costs) will reduce supplier activity, and increases in vacancies will also reduce supplier activity.

Finally, as noted above, there is ample evidence that supply adjustment to changes in price is sluggish and slow. We recognize this by including a variable measuring the lagged change in housing prices in the empirical model.

Vacancies in Owner-Occupied Housing

The early literature on vacancy in the rental housing market analyzed the empirical relationship between some "natural" rate of vacancy and housing rents, based on reduced form models (Eubank and Sirmans, 1979; Rosen and Smith, 1983). Theoretical explanations of vacancy focus on the frictions of search, given the idiosyncratic preferences of households and the heterogeneity of housing units (Arnott, 1989; Wheaton, 1990; Read, 1997). In these models, some level of vacancy facilitates the search process by housing demanders; sellers charge higher prices to cover the cost of maintaining vacancies. These search models provide insights on the unique aspects of housing markets, and they provide a rationale for housing vacancies in market equilibrium. More recently, Gabriel and Nothaft (2001) distinguished two components of vacancy, incidence, and duration, arguing that the incidence component is affected by population mobility and the duration component by search costs and the heterogeneity of the housing stock. Their empirical results suggest that residential rents are more responsive to the incidence component than the duration component.

[9]Housing stock at the beginning of the sample period is estimated from the number of households, ownership rates, and vacancy rates.

If a homeowner chooses to keep a unit vacant rather than selling in response to an offer, this is a decision to hold a real option. That is, when the owner of a vacant unit decides to keep a unit vacant rather than selling it at the current market price, this is because she believes that waiting is worthwhile. Waiting is more worthwhile if prices are expected to increase and if the volatility of housing investment returns is larger.

We thus specify the vacancy relationship as

$$v_t = \gamma_1 p_t + \gamma_2 N_t + \gamma_3 E(p_{t+1}) + \gamma_4 V(p_{t+1}) + \gamma_5 x_t^v \tag{7}$$

where $E(p_{t+1})$ and $V(p_{t+1})$ are the expectation and variance of future price changes, respectively, and x_t^v represents other exogenous shifters in vacancies. Again, lowercase letters represent logarithmic differences. We expect that increasing housing prices will lead to fewer vacancies. Higher expected price changes and a higher variance in housing prices will lead to higher current vacancies, and increased supply will lead to higher vacancies.

4. DATA AND METHODOLOGY

Data

The econometric evidence presented in the following section is based on data pieced together from a variety of sources. With one exception, the data series are publicly available, and most are available online. As noted above, we analyze three dependent variables: prices, vacancies, and supplier activity.

Single-family housing prices are measured using metropolitan housing price indices published by the U.S. Office of Federal Housing Enterprise Oversight (OFHEO).[10] The index is defined by the weighted repeat sales method[11] using all single-family houses whose mortgages have been purchased or securitized by Freddie Mac or Fannie Mae since 1975.

Homeowner vacancy rates by MSA are available annually from the U.S. Bureau of the Census.[12]

We measure supplier activity by the number of building permits issued for single-family housing in each MSA. Most prior research on housing supply is based upon aggregate housing starts (Topel and Rosen, 1988; DiPasquale and Wheaton, 1994; Mayer and Somervile, 2000). Information on housing starts is simply unavailable at the metropolitan level. However, it is well known that the aggregate series on permits tracks housing starts very closely (Evenson, 2001;

[10] http://www.ofheo.gov/house/faq.html.

[11] The repeat sales price index has the great advantage of standardizing housing prices for unmeasured quality. However, prices derived from this method at any point and time are subject to revision later, as subsequent transactions are included in the data. A "real time repeat sales" index would be preferred to an "ex-post repeat sales" index. See Clapham et al. (2005) for a detailed discussion and a comparison of these indexes.

[12] http://www.census.gov.

Somervile, 2001).[13] Other studies analyzing metropolitan data (e.g., Poterba, 1991; Drieman and Follain, 2003; Mayer and Somervile, 2000) also rely upon building permits. Data on building permits for single-family houses by MSA are recorded by the U.S. Bureau of the Census and are available online from the Real Estate Center at Texas A&M University.[14]

The equation for housing prices (5) includes structural variables measuring the user cost of housing capital and rents. Following many others (e.g., Kearl, 1979; Dougherty and Van Order, 1982; Mankiw and Weil, 1989), we specify the user cost of capital as

$$UC_t = M_t(1 - T_p)(1 - T_y) + DM - E(p_{t+1}) \tag{8}$$

where M_t is the mortgage interest rate, T_p is the property tax rate on housing, T_y is the marginal tax rate on income, DM is the depreciation and maintenance rate, and the last term is the expected tax-free capital gain on housing. The mortgage interest rate (for a 30-year fixed-rate contract) is reported by Freddie Mac.[15] In computing the user cost of capital in each year, we use the 1990 median tax rate in each metropolitan area as a percentage of house values,[16] assuming zero depreciation rate, and we estimate capital gains assuming AR-GARCH processes for each individual MSA. This procedure is explained in Appendix B.

Annual rents, R_t in each metropolitan area are obtained directly from the U.S. Department of Housing and Urban Development's (HUD's) measurement of rent at the 40th percentile of the distribution, so called, "Fair Market Rents."[17] In addition, we also include a lagged price-rent ratio, PD_{t-1}, to measure the expected implicit rent growth in housing.[18]

The estimated supply equation includes structural variables measuring input costs for labor and materials as well as financing costs. We also measure the stringency of regulations inhibiting new construction in each metropolitan area. Labor costs, LC_t, are measured by average earnings per worker in the construction industry by MSA and year, as reported in the Regional Economic Information System (REIS) database maintained by the Bureau of Economic Analysis.[19]

[13]At the national level, the correlation between housing starts and building permits is 0.95 from 1959 through 2000, and 0.99 during our sample period, 1987 through 1999.

[14]http://recenter.tamu.edu/data/bpm.

[15]http://www.freddiemac.com.

[16]http://www.bus.wisc.edu/realestate/resources/resdownl.htm.

[17]Fair Market Rents are annual estimates of gross rents at the 40th percentile published by HUD for 350 metropolitan areas and 2,350 nonmetropolitan county areas. Estimates are derived from the American Housing Survey and random digit dialing telephone surveys in each geographical area. See US Department of Housing and Urban Development (1995) for details of the estimation procedure. The data are available at http://www.huduser.org.

[18]Using the standard present value relation, the current dividend yield predicts the growth of future dividends. See Cochrane (1991).

[19]http://www.bea.doc.gov.

Proprietary metropolitan data on material costs for residential construction by year were obtained from the firm of Marshall and Swift. The data include separate cost estimates for structural steel columns and beams, reinforced concrete, masonry or concrete load bearing, wood or steel studs and metal bents, columns and girders. Rather than using all five series, we use the first two principal components of these costs, MC_t^1 and MC_t^2, which together explain 99 percent of total variation in the five series.

We measure the financing costs for housing suppliers by the prime interest rate f_t obtained from the DRI database.[20]

REG_t is an index of the stringency of regulation, which varies by metropolitan area, and is constructed using the results reported in Malpezzi (1996) and Malpezzi et al. (1998).[21]

We also employ several other exogenous variables in the three equations to measure the importance of the local economy. These include per capita income, Y_t, employment, EM_t, and per capita transfer payments for unemployment, UN_t. These data are all available from the REIS database.

A complete listing of variables, definitions and symbols is presented in Table 1. The subscripts i and t designate variables which vary by MSA and year.

5. EMPIRICAL RESULTS

Housing Prices

Alternative estimates for Equation (5) are reported in Table 2. All coefficients are estimated allowing for error components using two-stage least squares. (Baltagi, 1981; Hsiao, 1986). The coefficients on the changes in housing stock are significantly negative as expected. The magnitude of the estimated coefficients is unaffected when the vacancy variable is eliminated (Model V), suggesting independent roles for new construction and vacancies in the equilibrium price determination in metropolitan housing markets. The vacancy variable is negative as expected. (Increases in vacancies imply increases in housing units available for sale, which leads to decreases in prices.) The estimated coefficient for the rent variable is positive as expected, but it is insignificantly different from zero. As anticipated, the coefficient for the user cost measure is negative; it is highly significant in all five models. The estimated coefficients on dividend yields are small but significant for all specifications. This is consistent with the present value model, which suggests that lower dividend yields imply high dividend (rent) growth in the future. Homeowners expect house prices to go up when they anticipate rent growth in the future. The coefficients on the lagged endogenous variables are also all significant. The coefficient on the lagged price variable is around 0.5, implying that half of the discrepancy

[20] DRI is now called Global Insight. The data are available at http://www.globalinsight.com.

[21] See also http://www.bus.wisc.edu/realestate/resources/resdownl.htm.

TABLE 1: Description of Variables and Symbols

Symbol	Description
Dependent variables	
p_{it}	Difference in log of housing price in MSA i at time t
s_{it}	Difference in log of housing stock in MSA i at time t
v_{it}	Difference in log of vacancies in MSA i at time t
Other endogenous variables	
h_{it}	Difference in log of number of households
uc_{it}	Difference in log of user cost
r_{it}	Difference in log of rent
$E(p_{it})$	Expected rate of change in housing price
$\mathrm{Var}(p_{it})$	Variance of rate of change in housing price
Exogenous variables	
c_{it}	Input costs
mc_{it}^1, mc_{it}^2	Difference in log of material cost measure 1 and 2
lc_{it}	Difference in log of labor cost
f_{it}	Difference in prime interest rate
REG_i	Regulation index
$x_{it}^{P,S,V}$	Price, supply, vacancy shifters
y_{it}	Difference in log of personal income
em_{it}	Difference in log of employment
$x_{it}^{P,V}$	Price, vacancy shifters
un_{it}	Difference in log of unemployment compensation
x_{it}^{P}	Price shifter
$PD_{i,t-1}$	Log of price to rent ratio

between the market-clearing price and the observed price is eliminated within a year. Past increases in vacancies tend to decrease housing prices; homeowners expect lower prices this year when vacancies were higher last year.

Metropolitan macroeconomic conditions, household income and employment, affect housing prices. These effects are sizable in magnitude and significant in most cases. One exception is the employment growth in Model III, in which both household growth and employment growth are included. Given household growth, employment growth has only a limited effect on housing demand, implying that the major impact of changes in employment comes through changes in number of households.

Overall, the equations predicting housing prices appear to perform reasonably well at the metropolitan level. Coefficients are precisely estimated and the magnitudes are reasonable.

New Housing Supply

Table 3 reports the results for the housing supply models. The estimated supply elasticities are small but are highly significant, ranging from 0.01 to 0.09. Differences in elasticity estimates in housing supply across the five models imply that the supply elasticity depends on local macroeconomic variables.

TABLE 2: Estimates of Price Equation (t-ratios in parentheses)

	Model I	Model II	Model III	Model IV	Model V
s_{it}	−0.224	−0.316	−0.399	−0.120	−0.315
	(1.60)	(6.13)	(8.20)	(2.90)	(7.13)
v_{it}	−0.004	−0.031	−0.024	−0.043	
	(0.77)	(8.68)	(6.93)	(10.49)	
r_{it}	0.030				
	(0.44)				
uc_{it}	−0.509	−0.231	−0.185	−0.098	−0.219
	(11.58)	(6.74)	(5.61)	(2.63)	(6.52)
$PD_{i,t-1}$	−0.034	−0.019	−0.021	−0.020	−0.015
	(6.48)	(9.88)	(11.43)	(11.43)	(7.76)
p_{it-1}		0.570	0.480	0.515	0.481
		(29.07)	(25.33)	(25.93)	(25.14)
v_{it-1}				−0.019	
				(8.86)	
h_{it}	0.999	0.622	0.634		
	(6.38)	(10.26)	(7.73)		
y_{it}			0.515	0.355	0.267
			(11.29)	(8.24)	(5.58)
em_{it}			0.085	0.325	0.546
			(1.41)	(7.99)	(12.50)
σ_{it}^2	0.037	0.029	0.028	0.032	0.028
σ_i^2	0.130	0.156	0.037	0.034	0.064
σ_t^2	0.033	0.008	0.007	0.003	0.006

Note: Estimates are based upon annual observations on 74 MSAs during the period 1987–1999. Models are estimated by two-stage least squares (2SLS) in an error component framework. σ_i^2 and σ_t^2 represent the variance of time and MSA components of the error, and σ_{it}^2 is the variance of the white noise component.

Once the effects of local macroeconomic variables are controlled for, in Models IV and V, the elasticity is substantially decreased. This suggests that local business cycle might be just as informative for developers as housing market variables are. In Models III through V, vacancy is included. The estimated coefficient on the vacancy variable is small, but of course, price is already controlled for in these models. The coefficients on vacancy may act as an indicator for price volatility. If current vacancies are correlated with the future volatility of housing prices, then housing suppliers, observing high vacancies now, will delay new construction, anticipating future volatility. In contrast to many previous studies, the cost variables have the expected negative signs and are highly significant. The variables measuring materials costs are clearly important; the measure of labor cost has the expected sign, but is insignificant.[22] Capital cost,

[22]This may reflect the fact that the labor cost used is not the hourly wage, but rather per capita labor income in the construction industry, which includes both hourly wages and hours worked.

TABLE 3: Estimates of Supply Equation (t-ratios in parentheses)

	Model I	Model II	Model III	Model IV	Model V
p_{it}	0.094	0.042	0.021	0.009	0.011
	(13.57)	(8.00)	(4.65)	(2.12)	(2.26)
v_{it}			−0.002	−0.001	−0.001
			(4.16)	(2.87)	(1.18)
mc_{it}^1	−0.00003	−0.001	−0.001	−0.001	−0.001
	(0.10)	(5.34)	(8.35)	(8.19)	(5.70)
mc_{it}^2	−0.001	−0.000	−0.001	−0.000	
	(2.14)	(2.55)	(4.48)	(1.54)	
lc_{it}	−0.001				
	(0.17)				
f_{it}	−0.054	−0.021	−0.003		
	(2.65)	(2.06)	(0.45)		
REG_i	−0.015	−0.004	−0.005	−0.004	−0.004
	(1.63)	(3.61)	(3.68)	(4.08)	(3.27)
s_{it-1}		0.818	0.790	0.806	0.802
		(82.76)	(75.44)	(91.90)	(89.967)
p_{it-1}		−0.026	−0.009	−0.018	−0.021
		(7.44)	(2.93)	(6.30)	(6.702)
y_{it}				0.001	−0.004
				(0.12)	(0.61)
em_{it}				0.077	0.096
				(10.58)	(12.08)
Var(p_{it})					−0.088
					(2.70)
σ_{it}^2	0.006	0.003	0.003	0.003	0.003
σ_i^2	0.011	0.005	0.003	0.003	0.004
σ_t^2	0.033	0.004	0.005	0.003	0.003

Note: Estimates are based upon annual observations on 74 MSAs during the period 1987–1999. Models are estimated by 2SLS in an error component framework. σ_i^2 and σ_t^2 represent the variance of time and MSA components of the error, and σ_{it}^2 is the variance of the white noise component.

as measured by the prime interest rate, also has the expected sign, and is significant in two of the three specifications. The regulation index has the predicted sign, and the t-ratios are large; more stringent regulation acts to depress building activities. Housing price volatility is significant in Model V, indicating that the real option might be an important factor for suppliers' decisions.

Vacancies in Owner-Occupied Housing

Table 4 reports the estimates of the equation predicting vacancies in single-family housing. The coefficient on price is negative—higher prices mean that it is expensive to keep houses vacant. In all cases, the coefficients for housing prices are significant and negative. The coefficient on supply is significant and positive, as expected. The sign on the lagged vacancies is expected to be positive,

TABLE 4: Estimates of Vacancy Equation (t-ratios in parentheses)

	Model I	Model II	Model III	Model IV	Model V
p_{it}	−2.415	−1.938	−1.630	−2.179	−1.456
	(5.43)	(4.09)	(4.08)	(4.74)	(4.89)
s_{it}	1.348	1.311	2.324	1.933	1.577
	(2.04)	(2.00)	(2.70)	(1.99)	(2.76)
p_{it-1}	2.282	2.033	2.011	2.146	2.286
	(6.01)	(5.72)	(5.90)	(5.62)	(7.34)
v_{it-1}	−0.260	−0.249	−0.243	−0.256	−0.223
	(8.01)	(7.75)	(7.44)	(7.86)	(7.13)
y_{it}		−0.348			
		(0.46)			
em_{it}			−1.551		
			(1.86)		
un_{it}			−0.028		
			(0.49)		
h_{it}				−0.970	
				(0.84)	
$\mathrm{Var}(p_{it})$					10.926
					(2.27)
$\mathrm{Var}(p_{it-1})$					−13.519
					(2.73)
$E(p_{it})$					−2.491
					(4.33)
$E(p_{it-1})$					2.460
					(4.30)
σ_{it}^2	0.537	0.536	0.544	0.540	0.530
σ_i^2	0.452	0.384	0.353	0.433	0.190
σ_t^2	0.155	0.153	0.150	0.153	0.131

Note: Estimates are based upon annual observations on 74 MSAs during the period 1987–1999. Models are estimated by 2SLS in an error component framework. σ_i^2 and σ_t^2 represent the variance of time and MSA components of the error, and σ_{it}^2 is the variance of the white noise component.

reflecting the same sluggish response observed in movements in price and new construction. On the contrary, however, the sign on the past vacancies is negative and significant, implying that vacancies tend to overshoot. The regional macroeconomic variables have negative signs, that is, adverse shocks tend to increase vacancies, but they are statistically unimportant (except for employment growth in Model IV, which has a p-value of 0.06). Model V contains the conditional variances and expected returns to test for real option element in homeowners' decisions to keep houses vacant. The results are mixed. Overall, the vacancy equations have much higher error variances for all three components, indicating that the course of vacancies is relatively more difficult to predict using these economic variables.

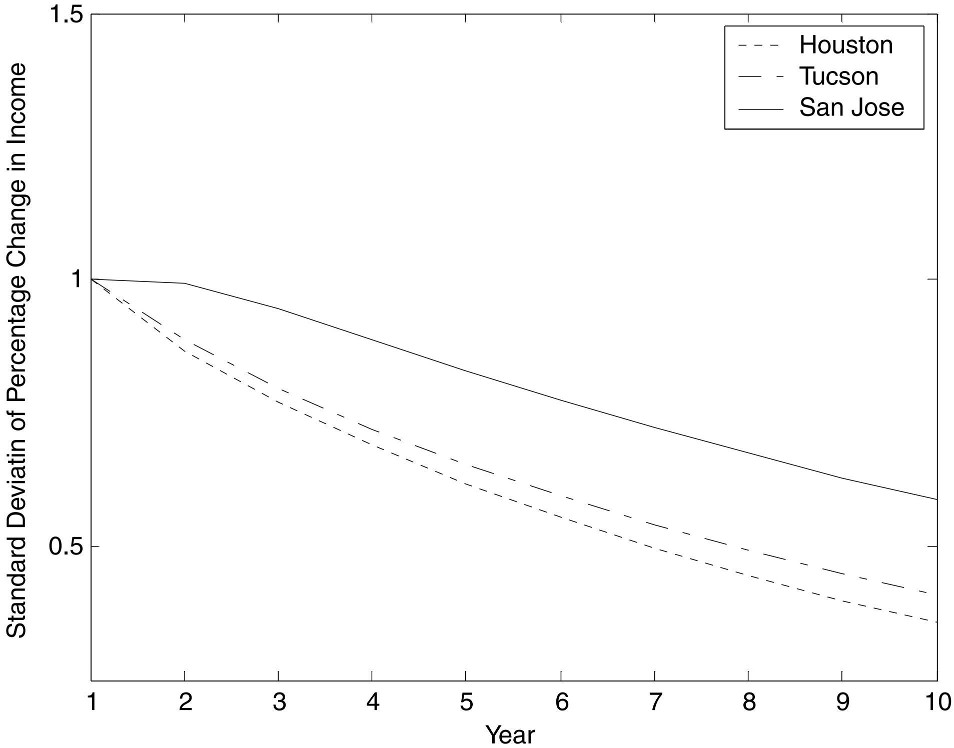

FIGURE 8: Impulse Responses of Income to an Unexpected Income Shock in Houston, Tucson, and San Jose.

Simulation

Another way to measure the implications of the model is to simulate the effect of exogenous shocks on the endogenous variables. We use estimates of Models II, III, and IV as the basis for simulation. Conventional simulation exercises specify a given change in some endogenous variable and trace its effects upon one or more endogenous variables. In this case, given the high correlation of local macroeconomic variables, we vary MSA income and employment growth jointly.[23] We select three metropolitan areas, San Jose, Tucson, and Houston, whose extreme patterns of house price development are depicted in Figure 1. In each case, we expose the local economy to an unexpected income shock of one standard deviation and we trace out the subsequent effects.

Figure 8 shows that the qualitative developments caused by an unexpected income shocks appear to be quite similar among the MSAs. The magnitudes of

[23]To accomplish this, we estimate a two-variable VAR model of income and employment by MSA and use the results to trace through the responses over time to a one standard deviation increase in MSA income.

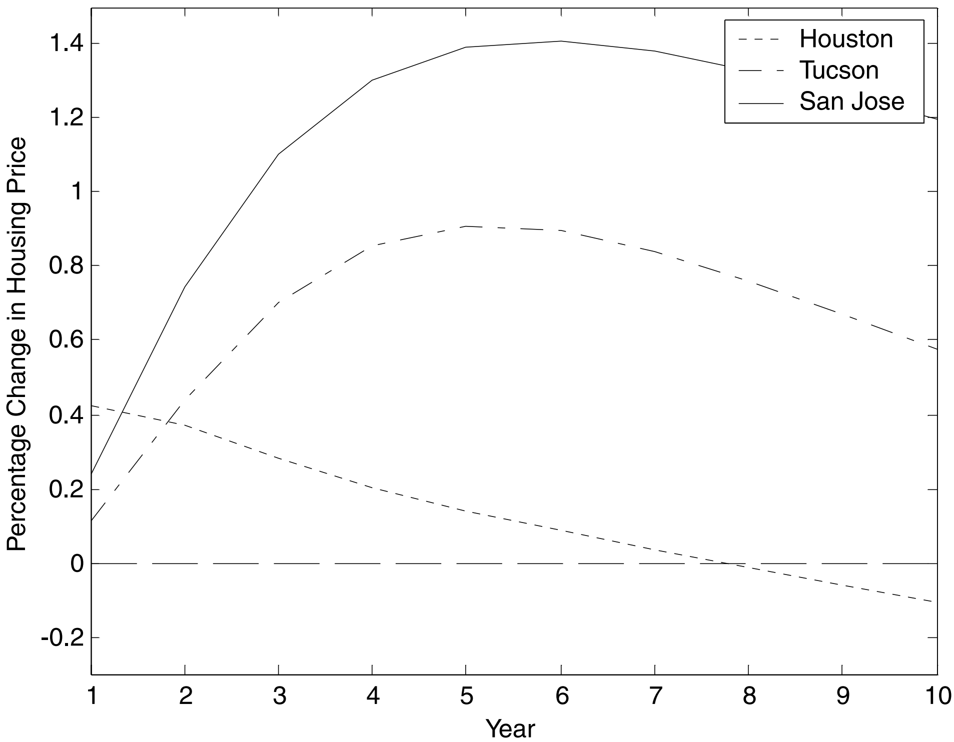

FIGURE 9: Housing Price Responses to Income Shock for Houston, Tucson, and San Jose.

initial income shocks range from 2.62 percent to 3.86 percent, and subsequent income shocks become smaller. It does take considerable time for these income shocks to be completely dissipated. Note that even though San Jose does not have the highest initial income shock, that shock is the most persistent in affecting subsequent income development.

Figure 9 shows the impact of the unexpected income shock on housing prices in these three markets. The initial price increase in Houston, one of the cities with the lowest housing return reported in Figure 1, is actually higher than that of San Jose and Tucson, but price increases dissipate very rapidly. In response to an exogenous increase in income, housing prices in San Jose and Tucson continue to increase for an extended period of time; the peaks in housing price appreciation occur after about 5 years. In the case of San Jose, housing prices never decline all the way back to the initial equilibrium during the subsequent 30-year period. This simulation exercise with housing prices suggests that the higher appreciation in housing prices in the last three decades may arise as much from the persistence of price appreciation as from the timing of initial shocks. After an initial shock, lagged market responses

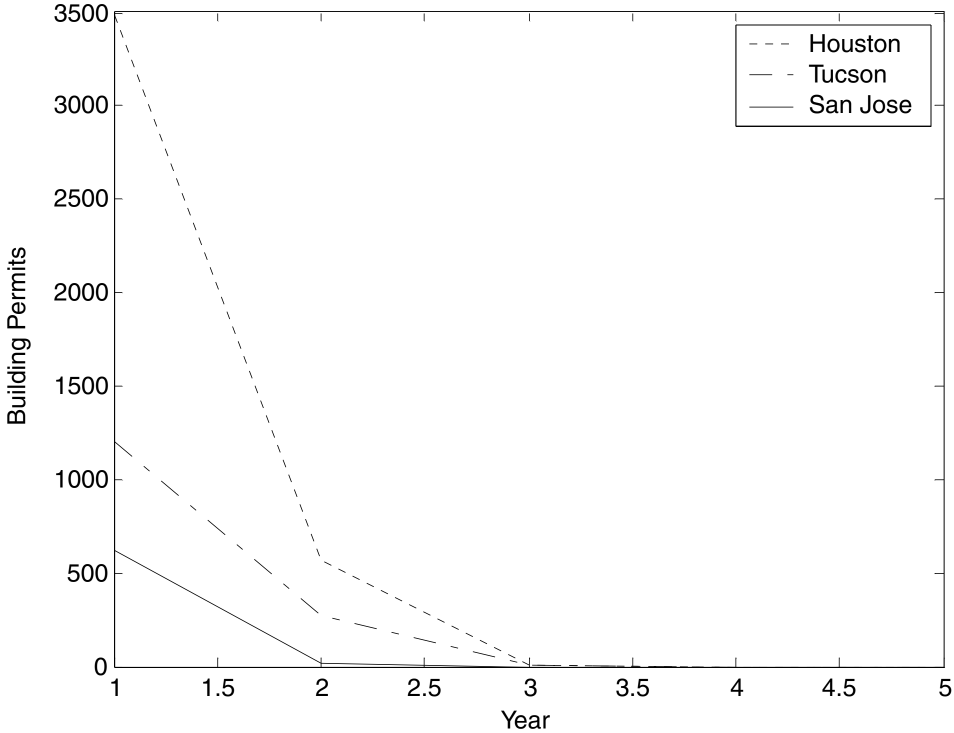

FIGURE 10: Construction Responses to Income Shock for Houston, Tucson, and San Jose.

play an important role in the development of equilibrium prices. Overall, the predicted housing price developments from the same model are quite distinctive among the three MSAs.

Figure 10 shows the response of construction activity to an unexpected income shock in these housing markets. Even though most of the response is dissipated in 3 years, the timing and magnitudes of the responses are remarkably different. Houston, the market with the lowest price appreciation, has a 1-year increase of about 3,500 dwellings, while Tucson (with medium price appreciation) has an increase of only 1,200 units. In San Jose, merely 600 units are added to the stock. Within the econometric model, a major reason for these large differences is the importance of regulation.[24] As noted in Figure 5, the relationship between housing returns and regulation is positive. This simulation exercise shows that this reflects the strong relationship between building activities and regulation. It also helps to understand the variations in housing price

[24] Houston has a regulation index value of 18.21, 6th lowest among 74 MSAs, and Tucson has 19.45, 35th lowest, while San Jose has 25.81, 7th highest.

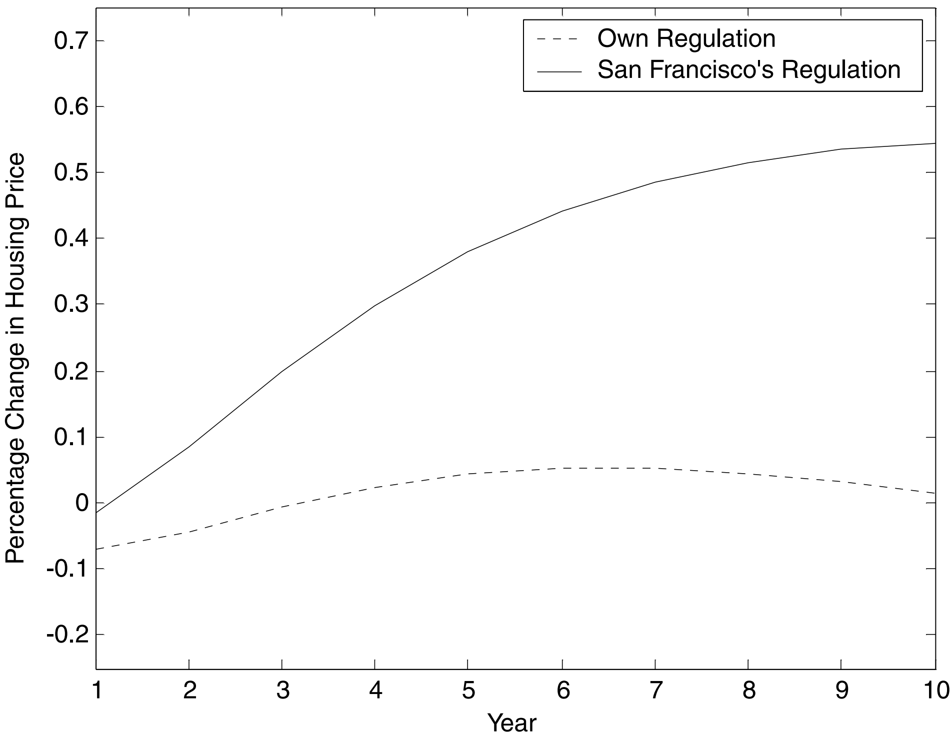

FIGURE 11: The Effects of Regulation in Housing Market: Denver MSA Housing Prices.

appreciation in Figure 9. A housing market with more stringent regulation has a more persistent price appreciation arising from an endogenous shock.

A second simulation may illustrate more clearly the importance of local regulation in affecting housing adjustment paths in metropolitan housing markets. In this simulation, we present the adjustment paths for housing prices, new dwellings, and vacancy rates for Denver, the metropolitan area with the lowest level of regulation in our sample. This simulation is conducted in the same manner as those reported for Houston, Tucson and San Jose. We also report a second simulation for Denver, but with one counterfactual. In this second simulation, we assume that Denver's regulation of new construction is as stringent as that of San Francisco, the market with the most stringent building regulations in our sample.

Figure 11 compares the effects of an exogenous increase in income on house prices. In Denver, there is a gradual, but modest impact on prices. Five years after the shock, housing prices have increased by about a tenth of a percent. However, with the regulations in force in San Francisco, the impact on housing prices in Denver would be substantial and persistent. Housing prices increase initially, and prices continue to rise subsequently. The differential impact on

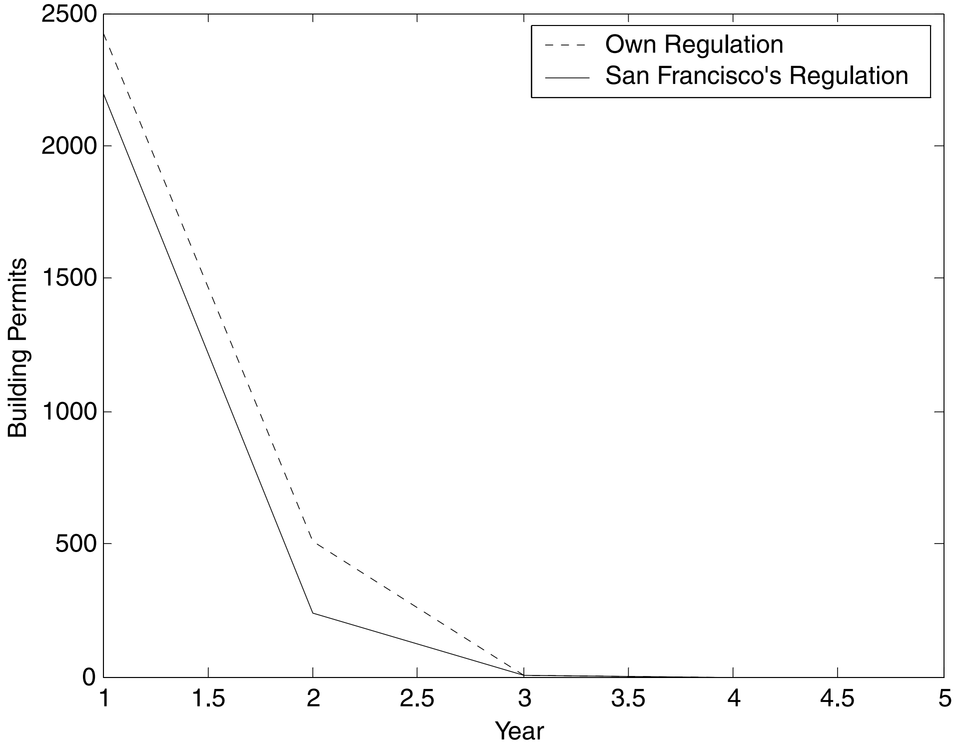

FIGURE 12: The Effects of Regulation in Housing Market: Denver MSA Building Permits.

new construction is also substantial. The general pattern appears to be similar; building permits rise upon impact, and return quickly to previous levels. However, under its current regulatory regime, the new supply of housing in Denver is larger by 10 percent than it would be under the more stringent regulations in effect in San Francisco (Figure 12). Vacancies fall more rapidly with more stringent building regulation (Figure 13). With a lower level of new construction, vacancies would be more responsive to increases in demand. Moreover, as price increases with more stringent regulations, homeowners find it more expensive to keep houses vacant.

6. CONCLUSION

This paper estimates the effects of national and regional economic conditions on local housing markets using a panel of U.S. metropolitan areas over a 14-year period. We estimate the effects of exogenous conditions on the prices and vacancy rates for owner-occupied single-family housing, and on building permits issued for new construction of single-family housing. The parameters are estimated by two-stage least squares in an error components framework.

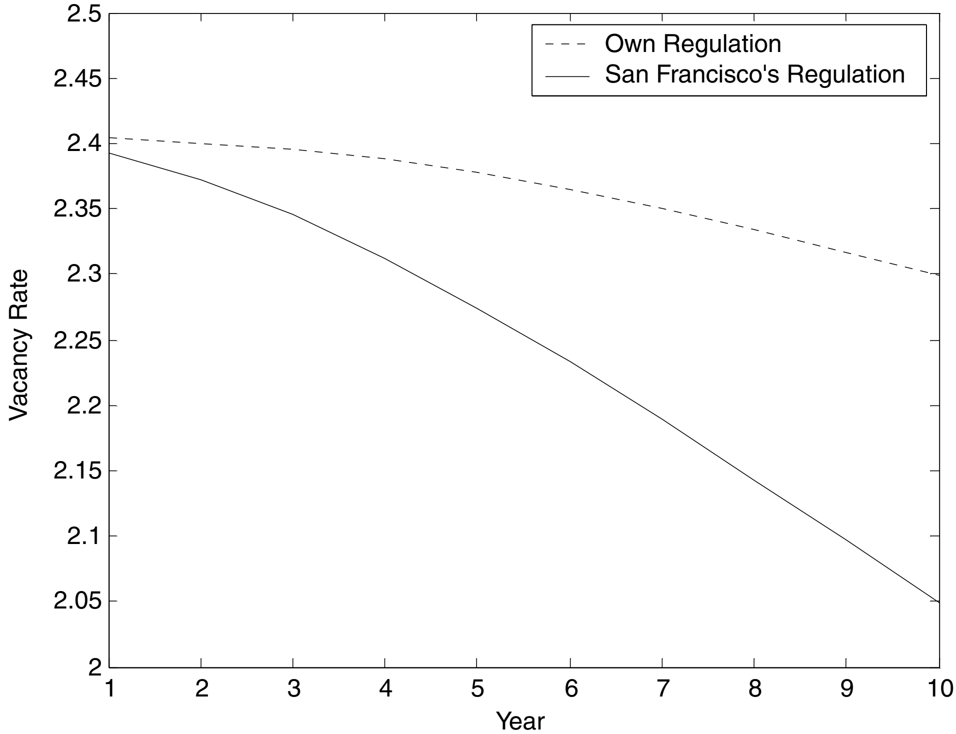

FIGURE 13: The Effects of Regulation in Housing Market: Denver MSA Vacancy Rates.

The empirical models provide a coherent set of empirical and simulation results. The results confirm the importance of changes in regional economic conditions, income and employment, upon local housing markets, and they confirm the importance of lagged adjustment processes on both the demand and supply sides of the market. The results also provide the first detailed evidence on the importance of vacancies in the owner-occupied housing market on housing prices and supplier activity. The results also document the importance of new supply and the factors—variations in materials, labor and capital costs, and regulation—affecting decisions to increase the supply of single-family housing.

Simulation exercises, using standard impulse response analyses, document the lags in market responses to endogenous shocks and the variations in response predicted from a common model depend greatly upon local conditions. Finally, the results suggest the importance of local regulation in affecting the pattern of market responses to regional economic conditions. In more regulated markets, levels of housing prices are higher in response to endogenous shocks, and the price increases are far more persistent over time.

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APPENDIX A

Approximation of Equation (3), the Equilibrium Condition for Housing Demand

Following Campbell, Lo and MacKinlay (1996),

$$\text{(A1)} \qquad \begin{aligned} \log\left(1+\frac{X}{Y}\right) &= \log\left(1+\exp\left(\log\left(\frac{X}{Y}\right)\right)\right) \\ &= \log(1+\exp(\log(X)-\log(Y))) \\ &= \log(1+\exp(x-y)) \cong \alpha+\beta(x-y) \end{aligned}$$

Consider Equation (1) in the text. Taking logs on both sides, and using Equation (A1) yields

$$\text{(A2)} \qquad \begin{aligned} \log(H_t)+\log(D_t) &= \log(S_t-V_t) \\ &= \log(S_t)+\log\left(1-\frac{V_t}{S_t}\right) \\ &= \log(S_t)+\gamma_1+\gamma_2(\log(V_t)-\log(S_t)) \\ &= \gamma_1+(1-\gamma_2)\log(S_t)+\gamma_2\log(V_t) \end{aligned}$$

Taking first-order differences in the above expression yields

(A3) $$\Delta\log(H_t) + \Delta\log(D_t) = (1-\gamma_2)\Delta\log(S_t) + \gamma_2\Delta\log(V_t)$$

Assuming linearity in (2) and solving for p^* yields expression (3) in the text.

APPENDIX B

Time Aggregation of Expected Housing Price Appreciation and Conditional Variances

This appendix shows how to calculate the expectation and conditional variance of *annual* housing price appreciation using *quarterly* observations.

Assume that r_t, quarterly housing returns, follows AR(4)-GARCH (1,1), that is,

(B1) $$r_t = \beta_0 + \sum_{k=1}^{4}\beta_k r_{t-k} + \varepsilon_t$$

where $\varepsilon_t = \sqrt{h_t}u_t$ and $u_t \sim$ iid N(0, 1) and $h_t = \gamma_0 + \gamma_1\varepsilon_{t-1}^2 + \gamma_2 h_{t-1}$

The conditional expectation and volatility of *annual* housing returns, given *quarterly* stochastic process (B1), are

(B2) $$E\left(\sum_{j=1}^{4} r_{t+j}\middle| I_t\right)$$

and

(B3) $$E\left[\left(\sum_{j=1}^{4} r_{t+j} - E\left(\sum_{j=1}^{4} r_{t+j}\middle| I_t\right)\right)^2\middle| I_t\right]$$

To calculate expected annual housing price appreciation in (B2), note that

(B4) $$r_{t+m} = E\left[r_{t+m} \mid I_t\right] + \sum_{n=1}^{m}\delta_n\varepsilon_{t+n} = C_m + \sum_{l=1}^{4} b_{m,l}r_{t-l+1} + \sum_{n=1}^{m}\delta_{m,n}\varepsilon_{t+n}$$

and

(B5) $$\begin{aligned} C_{m+1} &= C_m + b_{m,1}\beta_0 \\ b_{m+1,l} &= b_{m,1}\beta_l + b_{m,l+1} \quad \text{for } l < 4 \\ b_{m+1,4} &= b_{m,1}\beta_4 \\ \delta_{m+1,1} &= b_{m,1} \\ \delta_{m+1,n} &= \delta_{m,n-1} \quad \text{for } n > 1 \end{aligned}$$

Starting $m = 1$ and iterating over $m = 2$, 3, and 4, it is easy to compute (B2) using (B4) and (B5).

For the aggregation of conditional variances in housing returns over time, note that

(B6)
$$E\left[\left(\sum_{i=1}^{K} r_{t+i} - E\left(\sum_{i=1}^{K} r_{t+i}\middle| I_t\right)\right)^2 \middle| I_t\right]$$
$$= E_t\left[\left(\sum_{m=1}^{4}\sum_{n=1}^{m} \delta_{m,n}\varepsilon_{t+n}\right)^2\right]$$
$$= E_t\left[\left(\sum_{m=1}^{K}\sum_{n=1}^{m} \delta_{m,n}\left(\sum_{s=n}^{K}\delta_{s,n}\right)(\varepsilon_{t+n})^2\right)\right]$$
$$= \sum_{m=1}^{K}\sum_{j=1}^{m} \delta_{m,n}\left(\sum_{s=n}^{K}\delta_{s,n}\right)E_t\left(\varepsilon_{t+n}^2\right)$$

The term $\sum_{m=1}^{K}\sum_{j=1}^{m}\delta_{m,n}(\sum_{s=n}^{K}\delta_{s,n})$ can be computed using (B5). For $E_t(\varepsilon_{t+n}^2)$, note that

$$E_t\left(\varepsilon_{t+k}^2\right) = E_t(h_{t+k}) = \gamma_0 + \gamma_1 E_t\left(\varepsilon_{t+k-1}^2\right) + \gamma_2 E_t(h_{t+k-1})$$
$$= \gamma_0 + (\gamma_1+\gamma_2)(\gamma_0 + (\gamma_1+\gamma_2)E_t(h_{t+k-2}))$$
$$= \sum_{h=0}^{k-1}\gamma_0(\gamma_1+\gamma_2)^h + (\gamma_1+\gamma_2)^k h_t$$