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Regional Migration and House Price Appreciation

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Despite both empirical and anecdotal evidence suggesting the importance of common systematic factors determining price appreciation in residential real estate markets, the existing literature focuses almost exclusively on the impact of local variables. This paper presents a theoretical model of an urban housing market allowing for explicit consideration of the role of interregional migration in response to changes in economic opportunities within a system of cities. The model identifies the importance of aggregate income and aggregate population growth in house price appreciation and suggests that housing demand and population growth within regions are jointly determined. Empirical tests of these predictions provide strong support for the model. In particular, changes in per-capita aggregate income are negatively related to both returns to housing and local population growth and omitting this systematic component from empirical specifications leads to an underestimation of the impact of local income. Furthermore, there is significant evidence of endogeneity problems in empirical specifications of the model that are similar to those found in the existing literature.

Keywords

Housing; interregional migration; metropolitan growth

1. Introduction

The empirical literature on house prices in residential real estate markets focuses almost exclusively on the impact of local variables. While local economic conditions will certainly have an impact on the basic characteristics of housing markets, these markets are not islands lacking attachments to other elements of the economy as a whole. If households respond to regional differences in economic opportunities by migrating from one area to another, then variables characterizing economic performance in other areas should also be relevant.

This suggests that house prices should be influenced not only by local changes in income, but also by changes occurring outside of the region. This intuition is supported by a large body of work studying the determinants of interregional migration, including Gabriel et al. (1992), (1993) and Greenwood and Hunt (1989). Topel (1986) demonstrates that regional labor market variables, such as relative wages and interregional migration flows, are surprisingly flexible and correspondingly volatile, suggesting that labor demand plays a significant role in determining differences among metropolitan areas. Finally, turning to the housing markets literature, Gyourko and Voith (1992) provide evidence of a significant common national component in their analysis of long-run price appreciation across metropolitan areas within the United States.

The importance of changes in aggregate income and population arises due to a more general specification of equilibrium in our theory of urban housing markets. Typically, the theory used to characterize the determinants of house prices treat housing markets as being either open or closed. In the closed-city case, there is no migration into, or out of, the urban area; so there is no suggestion of outside influences, other than through the cost of capital. In the open-city case, migration does serve as an equilibrating mechanism, but the assumption of an exogenous fixed-level of utility implies that incomes within the city are perfectly negatively correlated with incomes in all other cities within the system.[1] As observed income growth is highly positively correlated across regions, results from open-city models may not provide meaningful insights into real world phenomenon. Finally, the empirical implications arising from such models depend crucially on which equilibrium case is assumed. In the open-city case, the model predicts that income and house prices would be perfectly co integrated, where there would be no expected relationship in the closed-city case.[2]

In the present setting, household migration decisions are treated as endogenous. This paper estimates a theoretical model of regional housing markets developed in Frame (2004), where households choose among employment opportunities offered by different metropolitan areas within a closed system of open cities. The basic intuition for this construction is found in Blanchard and Katz (1992) and Johnes and Hyclak (1999); given incomplete markets for risk sharing, households may respond to shocks to income by moving to another area offering better economic opportunities. Positive changes in local income that are large relative to shocks observed elsewhere within the economy encourage migration from outside of the region, increasing the demand for housing locally. Within the areas experiencing relatively negative shocks, the net out migration will have the opposite

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[1] See Frame (2004) for a more detailed discussion.

[2] Gallin (2006) finds no evidence of cointegration between house prices and income. This may be due, in part, to less migration than what is predicted by models employing the equilibrium assumptions associated with the open city case.

effect. These migration induced changes in the demand for housing, both positive and negative, influence house prices, which serve as equilibrating mechanisms.

By evaluating household location decisions within this more general environment, relations describing equilibrium prices for housing and local populations identify several issues relating to housing demand which are not reflected currently in the corresponding empirical literature. Within this context, growth rates for local populations and house prices are determined simultaneously and by a common subset of independent variables. In particular, both can be expressed as functions of both regional variables, such as per-capita income growth, and by macroeconomic variables such as average per-capita income growth within the system and aggregate population growth. By considering migration decisions explicitly in this manner, household income becomes an important element not in isolation, but in relation to aggregate income.

In addition to identifying and providing evidence of the importance of macroeconomic variables in the determination of house prices and price appreciation, the model also provides arguments and evidence supporting the facts observed in Gyourko et al. (2006), but by considering differences in economic performance across metropolitan areas rather than unobserved heterogeneity in the preferences for location and a restricted supply of housing. Gyourko et al. propose that superstar cities are those that are relatively attractive to households within the economy, but are supply constrained due to either land use restrictions or the natural characteristics of the land surrounding the area. The relative desirability attracts those households most willing, and able, to pay, resulting in increasing income inequality within the city in question. As income grows in the economy as a whole, this combination of wealthy and mobile households and supply restrictions results in greater than average growth in house prices in these cities. A possible problem with their analysis is that income is generally tied to a place of residence. In the superstar cities construct, households are not only able to change cities, but can also bring their job along with them. While housing markets within a few cities within the United States may be dominated by changes in population not related to labor income, retirement communities in Arizona, for example, this disconnect between income and jobs will not serve as the general case.

In order for residents to move from one city to another, they must be able to secure employment in their desired location offering them an income sufficient to allow them to live there. In Frame (2004) higher house prices and above average appreciation are linked to above average economic performance by a region. In metropolitan areas experiencing increased demand for their products, firms demand more labor and, once the qualified unemployed labor pool within the region is exhausted, must provide sufficient compensation to encourage migration into the region from other regions within the country. As house prices rise due to the increase in local population, firms must offer higher wages than offered in other areas in order to compensate workers for their increased cost of housing. If these superstar cities are experiencing above average economic growth, then the predictions of the model derived in Frame correspond precisely to the empirical observations contained in Gyourko et al. even without restrictions on the supply of housing.

The outcomes associated with this model immediately suggest two potential biases in the existing empirical literature. First, many papers include measures of both income and net migration as independent variables explaining the determinants of the price of housing. The simultaneity of population and house price appreciation, in conjunction with the similarity in explanatory variables, points to an endogeneity bias leading to inconsistent estimates of coefficients. Changes in income will affect both house price appreciation and net migration. Second, there is the possibility of omitted variable bias. With few exceptions, empirical estimates of local house prices include local household income alone, not accounting for differences in incomes across regions. By omitting some relative basis, not only will OLS estimation lead to biased coefficient estimates, but will also bias the variance-covariance matrix, leading to problems with inference. Such misspecifications could undermine the stated conclusions of these papers.

The empirical results obtained by estimating this model correspond quite well to our predictions, identifying both regional and aggregate factors affecting house price appreciation. Rising regional per-capita income leads to greater house price appreciation and greater in migration, while higher aggregate average per-capita income has the opposite effect. There is also strong evidence of an endogeneity bias in typical specifications in empirical models of housing demand.

There is an existing literature addressing some of the same issues. Gabriel et al. (1999) look at role of migration in explaining differences in house prices and house price dynamics across Los Angeles and San Francisco metro areas within California. They find that net migration is a major factor in the performance of California's metropolitan housing markets during the 1980s and 1990s. Gabriel et al. (1992) examine the effects of regional house price dispersion on migration decisions, identifying the importance of relative wages and demonstrating empirically that relatively high house prices in destination cities are an impediment to interregional migration. Capozza et al. (2004) recognize the importance of relative economic performance, finding that faster growth in both population and real income is associated with more serial correlation in house price appreciation. Finally, Potepan (1994) identifies the potential for simultaneity between house prices and population and estimates a simultaneous equation model, but finds rather mixed results and considers only absolute measures, as opposed to relative, measures of economic opportunity.

The paper is organized as follows. Section 2 develops a dynamic model of migration and rent determination in housing markets within the context of a closed system of open cities. In section 3, empirical counterparts to the theoretical house price and population growth are developed and estimated and implications of the model for the existing literature are discussed. A summary and extensions are provided in the final section.

2. Model

The model presented in Frame (2004)] generalizes the growing urban economy analyzed in Capozza and Helsley (1990) by replacing the small, open city environment, where the level of household utility is fixed, with a closed system of $I < \infty$ cities. In this setting, the population of the system is given exogenously and residents can migrate between the cities within the system without cost. First, the general characteristics of the system's residents are described, then intra- and inter-city equilibrium conditions can be determined, leading to the derivation of rent, price, and population processes corresponding to the characteristics of the underlying income processes.

Within city $i \in \{1,2,\ldots,I\}$, household income is determined identically for all residents according to a given stochastic process, $y_i(t)$, which has a positive expected growth rate and may be contemporaneously correlated with the income processes of residents in other cities. Households work within a centrally located business district (CBD) and reside within a featureless plane surrounded by land having value to an agricultural sector. A household's location relative to the CBD is denoted by $u \geq 0$, the round-trip distance from home to work. Location is relevant to household decisions due to the cost of commuting to and from the CBD. Distance is normalized so that the round-trip commuting cost for a given household equals one unit of income. Residents within the system are identical in terms of their preferences; receiving utility from a numeraire composite consumption good, $x_i(u,t)$ and housing, $h_i(u,t)$ represented by utility function $V(x_i(u,t), h_i(u,t))$. For simplicity, it is assumed that each household contains one resident that consumes one unit of infinitely durable housing which is constructed on one unit of land. Given the fixed nature of housing, we can suppress the dependence of utility on $h_i(u,t)$ by letting $v(x_i(u,t)) \equiv V(x_i(u,t),1)$. Under these assumptions, the budget constraint for a household at time t in city i at location u is given by

$$y_i(t) = x_i(u,t) + r_i(u,t) + u,$$

where $r_i(u,t)$ is rent per unit of housing.

2.1. Intra-city Equilibrium

Within a given city, rents adjust so that households cannot increase welfare by moving within the community. This requires that all households within city i receive the same level of utility at each moment in time and that the demand for land within equals supply for a given population, $n_i(t)$.

It is assumed that residential development takes place within a rectangular plane of width one, where the outer boundary of the community is denoted by $b_i(t)$ Land beyond the boundary of the community is rented to an agricultural sector for r^a per unit of land, regardless of location relative to the CBD. Given uniform residential density and a fixed population to household ratio of one, demand for land is simply given by the population. Equating supply and demand then requires $b_i(t) = n_i(t)$ for all t.

As the boundary of the city expands, developers convert undeveloped rural land to residential use the first time that the rent corresponding to land in urban use exceeds a reservation rent, $r_i(u,t) \geq r_i^*$. The value of this reservation rent relative to the rent paid by the agricultural sector determines the timing of development.

Given uniformity in housing consumption, it must be the case that all households receive the same consumption regardless of location, $x_i(u, t) = x_i(t)$ for all u, t , and for each i. Using the fact that all households consume equally, and that the rent at $b_i(t)$ is given by r_i^* , the rent at any urban location within city i can be expressed as

$$r_i(u,t) = r_i^* + n_i(t) - u.$$

3.2 Inter-city Equilibrium

Equilibrium within the system of cities at time t is determined by the joint requirements that households are indifferent among cities, and that the total population is allocated completely between cities. In this environment, migration between cities occurs whenever there are realized differences in welfare across cities. Given costless migration and identical preferences for land and consumption, indifference among cities within the region requires $v(x_i(t)) = v(x_j(t)), \forall i , j$, which, in turn, implies $x_i(t) = x_j(t) = x(t)$ for all $\forall i , j$ and $t \geq 0$. Using this in conjunction with the household's budget constraint implies

$$x(t) = y_i(t) - r_i^* - n_i(t)$$

for all i, t.

An additional requirement of the inter-city equilibrium is that the sum of the populations of each city equals the population of the system, $N(t)$, in each period. Formally, this requires

$$\sum_{k=1}^{I} n_k(t) = N(t)$$

for all t. It is assumed that the process determining aggregate population is growing deterministically at a given rate.

Taking r_i^* as given, the rent and population of city i are given by

$$r_i(u,t) = y_i(t) - \frac{1}{I}\left[\left(\sum_{k=1}^{I} y_k(t) - r_k^*\right) - N(t)\right] - u, \tag{1}$$

and

$$n_i(t) = y_i(t) - \frac{1}{I}\left[\sum_{k=1}^{I} y_k(t) - N(t)\right] - \left(r_i^* - \frac{1}{I}\sum_{k=1}^{I} r_k^*\right), \tag{2}$$

respectively.

Given (1) and (2), rental and population growth can be expressed in terms of differentials

$$dr_i(u,t) = dy_i(t) - \frac{1}{I}\left[\sum_{k=1}^{I} dy_k(t) - dN(t)\right] \tag{3}$$

$$dn_i(u,t) = dy_i(t) - \frac{1}{I}\left[\sum_{k=1}^{I} dy_k(t) - dN(t)\right] \tag{4}$$

In competitive markets, the price of land equals the expected present value of future rents. If land owners are risk neutral and share a common user cost of capital, *q(t)*, the price of urban land at location $u \le b_i$ in city *i* at time *t* is given by

$$P_i(u,t) = \mathrm{E}\left[\int_t^\infty r_i(u,\phi) e^{-q(\phi-t)} d\phi \middle| r_i(u,t)\right]$$

$$= \mathrm{E}\left[\int_t^\infty \left(y_i(t) - \frac{1}{I}\left[\left(\sum_{k=1}^{I} y_k(t) - r_k^*\right) - N(t)\right] - u\right) e^{-q(\phi-t)} d\phi\right]. \tag{5}$$

House price appreciation is given by

$$dP_i(u,t) = \left[\int_t^\infty \left(dy_i(t) - \frac{1}{I}\left[\sum_{k=1}^{I} dy_k(t) - dN(t)\right]\right) e^{-q(\phi-t)} d\phi\right], \tag{6}$$

representing the capitalized value of rental income growth.

3. Empirical implications

What do equations (4) and (6) tell us about behavior in local housing markets? First, and foremost, rents, populations, and prices are determined simultaneously by similar factors. In particular, these equations are functions of local income relative to the average income received by households within the system and aggregate population. After briefly describing the empirical counterparts to (4) and (6), and the sources of data used, the model is estimated and empirical evidence of potential biases in typical specifications of house price equations is discussed.

3.1 Empirical model

Equation (6) expresses the annual change in the price of housing in region *i*, ΔPi, as a function of annual changes in regional per capita income, Δyi, average national per capita income, ΔY, population of the system, ΔN, discount rate, q, and change in the discount rate Δq. The annual change in regional population, Δni, as characterized by (4), is a function of the same income and population variables.

The empirical counterparts to (4) and (6) are given by

$$\Delta Pi = \delta i + \alpha_1 \Delta yi + \alpha_2 \Delta Y + \alpha_3 \Delta N + \alpha_4 q + \alpha_5 \Delta q + \varepsilon i \tag{7}$$

$$\Delta ni = \gamma i + \beta_1 \Delta yi + \beta_2 \Delta Y + \beta_3 \Delta N + \nu i, \tag{8}$$

for each I = {1,2,…9} , where δi and γi are regional dummy variables, and $\varepsilon i, \nu i$ are error terms.

4. Data

For the purpose of the present analysis, the United States will be treated as a system composed of the nine census divisions: New England, Middle Atlantic, East South Central, West South Central, East North Central, West North Central, Mountain, and Pacific. The house price data comes from the Freddie Mac/Fannie Mae Conventional Mortgage Housing Price Index (CMPHI), covering a period from 1975 to 2001 and is reported at the census division level.3 The CMHPI are constructed using a weighted repeat-sales method, as described in Case and Shiller (1989), which controls for differences in housing quality. As some of the required data are available only on an annual basis, annual indices are created by averaging the quarterly observations from the CMPHI.4 House price appreciation in region i is represented by the differences in the natural logarithms of the price over a given period of time. The gross population growth rate for the region is defined similarly.

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[3] http://www.freddiemac.com/news/finance/data.html

[4] While averaging the data reduces the volatility of the index, see Geltner (1993), it does retain as much of the information as possible by including all observations.

Population and per capita income information comes from the Bureau of Economic Analysis Regional Accounts Data.[5] These data are not reported at the census division level, so the metropolitan components of state-level data were used to create the corresponding regional indices. Population data are aggregated, per-capita regional income is determined by the population-weighted average of each state's income. Finally, conventional mortgage data comes from Board of Governors of the Federal Reserve Bank.[6]

In addition to those variables identified in (4) and (6), several control variables will be used in the estimation. In the house price appreciation equation, Case and Shiller (1989) provide evidence of serial correlation, suggesting that lagged returns, ΔP_i, should be included. As changes in local populations appear to be serially correlated, lagged growth, Δni, is also included as an independent variable in the case of local population growth. Finally, as mentioned above, regional dummy variables are included to capture un-modeled systematic differences across regions.

The data are assembled into a panel with nine cross sections with 27 observations on each, for a total of 243 observations. With the exception of mortgage rates, which are determined by the annual difference in rates, changes are computed as the difference in logarithms, approximating annual growth rates. Given this, ΔPi serves as an approximation of annual house price appreciation within region i .

Table 1 Composition of Census Divisions

Census Division	States
New England	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
Middle Atlantic	New Jersey, New York, Pennsylvania
South Atlantic	Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia
East South Central	Alabama, Kentucky, Mississippi, Tennessee
West South Central	Arkansas, Louisiana, Oklahoma, Texas
West North Central	Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota
East North Central	Illinois, Indiana, Michigan, Ohio, Wisconsin
Mountain	Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
Pacific	Alaska, California, Hawaii, Oregon, Washington

[5] http://www.bea.doc.gov/bea/regional/data.htm

6 As the value of the property is partially a function of options in both the debt used to finance the property and in the potential to renovate or redevelop the property at a later date, the proper discount rate should reflect the values of these options to some point. Given this, the mortgage rate is the appropriate discount rate in this setting. For further discussion, see Berk (1999). The mortgage data can be found at http://www.federalreserve.gov/releases/h15/data.htm

Table 2 Descriptive statistics

Variable	Mean	Std. Dev.
ΔPi	0.0571	0.0465
Δni	0.0126	0.0085
Δyi	0.0627	0.0282
ΔY	0.0619	0.0268
ΔN	0.0118	0.0137
q	0.1007	0.0269

5. Empirical Results

5.1 Endogeneity of Local Population Growth

The simultaneous nature of migration and housing demand decisions points to a potential endogeneity bias in existing empirical models of housing markets. If the basic intuition associated with the model presented here is correct, any estimation by ordinary least squares (OLS) where house prices are a function of both local income and local population will be inconsistent due to correlation between local population and the error term. As demonstrated in the previous section, this will be true for estimates involving both price levels and rates of change. Examples of models employing this type of specification include Capozza and Schwann (1990), Jud and Winkler (2002), Ozanne and Thibodeau (1983), and Potepan (1996).

Is there evidence of endogeneity? Two related tests can be used. Davidson and MacKinnon (1993) suggest an augmented regression test, referred to as the Durbin-Wu-Hausman (DWH) test, which can be performed by including the residuals of the potentially endogenous variable, Δni, as a function of all exogenous variables in the original regression involving house price appreciation, ΔPi. If the coefficient on the residuals is significantly different than zero, then the null hypothesis of exogeneity can be rejected. Using a specification of the model approximating those in the existing literature, the corresponding F-statistic, with 1 and 19 degrees of freedom is 6.60, implying a p-value of approximately .01, which is small enough to reject the null hypothesis of exogeneity. An alternate test, allowing for some quantitative measure of the importance of the bias, was proposed by Hausman (1978). This test compares the estimated coefficients from a two-stage least squares (2SLS) regression to the coefficients obtained in the original OLS specification. If Δni is exogenous, differences in coefficients should be due only to sampling error. In this case, using the regional dummy variables as instruments, the t-statistic is approximately -2.5, suggesting that the null hypothesis of exogeneity can be rejected with a high degree of confidence. These results suggest that OLS regression overstates the impact of population growth on house price appreciation relative to the 2SLS case. Given this, consistent estimates of coefficients on the factors influencing local house price require either 2SLS or estimation of systems of equations.

Table 3 Endogeneity (Hausman Test)

	Dependent variable : ΔRi	
Independent Variable	OLS	2SLS
Change in regional population (Δni)	0.4270* (2.54)	0.2170 (1.12)
Change in regional income (Δyi)	0.7717** (9.36)	0.7707** (9.319)
Change in mortgage rate (Δq)	-0.3671** (7.494)	-0.3491** (7.03)
Lagged regional housing appreciation (lag ΔPi)	0.6997** (17.55)	0.7120** (17.67)
Number of observations	225	
Hausman *t*-statistic : $\beta_{2SLS}-\beta_{OLS}\left(\beta_{2SLS}-\beta_{OLS}\right)/\left(se\left(\beta_{2SLS}\right)^2-se\left(\beta_{OLS}\right)^2\right)^{1/2}=-2.49$		
Instruments used in 2SLS : NE, MA, SA, ESC, WSC, WNC, ENC, MTN, PAC		
** denotes significance at the 1% (or better) level		
* denotes significance at the 5% (or better) level		

While reaching the same conclusion as Potepan (1994) regarding the endogeneity of local population, the relative size of the coefficients in the Hausman test are reversed. This may be due to Potepan's use of potentially endogenous variables, employment and unemployment, as instruments when performing the Hausman test or the absence of controls for relative economic performance.

6.2 The influence of aggregate factors

Equations by (4) and (6) suggest that both the average growth rate of per-capita income for the system as a whole and aggregate population growth will influence both regional population growth and house price appreciation. Omitting potentially influential variables can result in biased estimates of coefficients of the included independent variables. It should be expected that the estimated coefficients on regional per-capita income will be biased in a downward manner. The model suggests that migration will occur only when regional income growth exceeds the average per-capita income growth for the system as a whole. If ΔY is not included in the model, then there may be cases when an increase in regional income is associated with house price depreciation and negative regional population growth.

As the empirical relations (7) and (8) are expressed as reduced form equations, independent estimation by OLS is appropriate. Given the supposition that growth in local population and house price appreciation are determined simultaneously, it is not surprising that this procedure produces residuals that are positively correlated across equations, $\rho_{\varepsilon i v i}=.34$. This suggests that more efficient estimates of the coefficients can be obtained by estimating the equations as a system using seemingly unrelated regression (SUR).

The estimated coefficients obtained from the SUR are presented in Table 4 and are generally consistent with the hypotheses implied by (4) and (6). Local population growth and house price appreciation are positively related to changes in regional per-capita income and negatively related to changes in average per-capita income for all households within the system. This appears to be strong evidence that changes in relative income are an important component determining house price appreciation and household migration decisions. As suggested, changes in local income will have the greatest impact on the local housing market when coming at a time when other regions within the economy are not performing as well.

Table 4 Estimated Coefficients from SUR

	Dependent variable	
Independent variable	ΔPi	Δni
Regional income growth Δyi	1.1061** (6.55)	0.1154** (6.86)
Average per capita income growth (ΔY)	-0.6148** (3.25)	-0.1040** (5.58)
Aggregate population growth (ΔN)	-4.8491** (2.71)	0.5299** (3.20)
Change in mortgage rate (Δq)	-0.5389** (3.52)	
Mortgage rate (q)	-0.4641** (7.21)	
Lagged regional housing appreciation (*lag* ΔPi)	0.6610** (17.87)	
Lagged regional population growth (*lag* Δni)		0.7418** (22.30)
New England (*NE*)	0.0918** (3.27)	-0.0063** (2.69)
Middle Atlantic (*MA*)	0.0932** (3.33)	-0.0063** (2.69)
South Atlantic (*SA*)	0.0925** (3.30)	-0.0022 (0.93)
East South Central (*ESC*)	0.0877** (3.13)	-0.0059* (2.06)
West South Central (*WSC*)	0.0883** (3.15)	-0.0025 (1.04)
West North Central (*WNC*)	0.0950** (3.38)	-0.0047* (2.00)
East North Central (*ENC*)	0.0947** (3.37)	-0.0049* (2.08)
Mountain (*MTN*)	0.0932** (3.32)	-0.0006 (0.24)
Pacific (*PAC*)	0.1017** (3.62)	-0.0020 (0.86)
R^2	0.7726	0.9243
Number of observations		225
** denotes significance at the 1% (or better) level		
* denotes significance at the 5% (or better) level		

Growth in aggregate population contributes positively and significantly to local population growth, but negatively to house price appreciation. While the former is as predicted, the latter is contrary to the theoretical model. A contributing factor may be that the series of changes appears to be non-stationary, as the change in aggregate population grows at an increasing rate during the sample period. On the other hand, the change in aggregate population is due in large part to births and deaths. The impact on the demand for housing will be negative and immediate for deaths and, while positive, could be delayed significantly for births. The coefficients on other variables normally included in the existing empirical literature are consistent with results presented elsewhere.

Table 5 Estimated Coefficients from SUR

	Dependent variable	
Independent variable	ΔPi (including ΔY , ΔN)	Δni (including ΔY , ΔN)
Regional income growth Δyi	1.1061** (6.55)	0.7029** (8.58)
Average per capita income growth (ΔY)	-0.6148** (3.25)	
Aggregate population growth (ΔN)	-4.8491** (2.71)	
Change in mortgage rate (Δq)	-0.5389** (3.52)	-0.74839** (5.51)
Mortgage rate (*q*)	-0.4641** (7.21)	-0.3988** (6.48)
Lagged regional return to housing (*lag* ΔPi)	0.6610** (17.87)	0.6817** (18.05)
New England (*NE*)	0.0918** (3.27)	-0.0160* (2.09)
Middle Atlantic (*MA*)	0.0932** (3.33)	-0.0157* (2.08)
South Atlantic (*SA*)	0.0925** (3.30)	-0.0147 (1.963)
East South Central (*ESC*)	0.0877** (3.13)	0.0118* (1.36)
West South Central (*WSC*)	0.0883** (3.15)	0.0100 (1.34)
West North Central (*WNC*)	0.0950** (3.38)	0.0126 (1.68)
East North Central (*ENC*)	0.0947** (3.37)	0.0154* (2.07)
Mountain (*MTN*)	0.0932** (3.32)	0.0147* (1.96)
Pacific (*PAC*)	0.1017** (3.62)	0.0217** (2.87)
R^2	0.7726	0.7614
Number of observations		225
** denotes significance at the 1% (or better) level		
* denotes significance at the 5% (or better) level		

Tables 5 and 6 provide comparisons of estimates in models including aggregate factors ΔY and ΔN. In both equations, the addition of aggregate income growth increases the value of the estimated coefficients on local per capita income growth. In the equation determining regional population growth without these variables, the coefficient on regional income growth becomes indistinguishable from zero.

Table 6 Estimated Coefficients from SUR

Independent variable	Dependent variable: ΔPi (including ΔY, ΔN)	Dependent variable: Δni (including ΔY, ΔN)
Regional income growth Δyi	0.1154** (6.86)	.0073 (1.18)
Average per capita income growth (ΔY)	-0.1040** (5.58)	
Aggregate population growth (ΔN)	0.5299** (3.20)	
Lagged regional population growth (*lag* Δni)	0.7418** (22.30)	0.7946** (21.57)
New England (*NE*)	-0.0063** (2.69)	0.0008 (1.09)
Middle Atlantic (*MA*)	-0.0063** (2.69)	0.0003 (0.53)
South Atlantic (*SA*)	-0.0022 (0.93)	0.0035** (3.75)
East South Central (*ESC*)	-0.0059* (2.06)	0.0014 (1.80)
West South Central (*WSC*)	-0.0036 (1.52)	0.0031** (3.25)
West North Central (*WNC*)	-0.0047* (2.00)	0.0015* (2.01)
East North Central (*ENC*)	-0.0059* (2.53)	0.0011 (1.64)
Mountain (*MTN*)	-0.0006 (0.24)	0.0046** (4.07)
Pacific (*PAC*)	-0.0020 (0.86)	0.0032** (3.49)
R^2	.9243	0.9047
Number of observations		225
** denotes significance at the 1% (or better) level		
* denotes significance at the 5% (or better) level		

7. Summary and extensions

Within a simple model of a regional housing market, it has been demonstrated that house price appreciation and changes in regional populations are influenced by aggregate economic factors and determined simultaneously by a common subset of exogenous variables. This suggests that by considering house price appreciation and regional population growth within the context of a closed system of open cities, there is evidence of potential omitted variable and endogeneity biases that may undermine the findings presented in existing empirical studies. With the exception of the negative influence that aggregate population growth appears to have on house price appreciation, the predictions of the theoretical model are consistent with the empirical results.

Moving from a model of interregional migration to a model of relocation between countries requires considering differences in nationally determined public policy. As barriers to migration between countries in the European Union declined, one implication of the finding presented here is that the local housing markets should exhibit a greater sensitivity to the economic performance of neighboring countries due to greater migration of workers between countries. The degree of migration between countries has not increase significantly. Hassler et al. (2005) argue that such a relative lack of mobility in Europe may be explained by differences by higher levels of unemployment insurance relative to the United States.

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