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U.S. Regional Population Growth 2000-2010: Natural Amenities or Urban Agglomeration?

by

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Abstract. Using a spatial hedonic growth model, this paper empirically examines the relative roles of natural amenities and urban agglomeration economies as determinants of U.S. regional growth patterns from 2000 to 2010. Natural amenities and urban agglomeration are measured using the USDA Economic Research Service county classification codes. The general finding is that natural amenities and urban agglomeration both influenced regional growth. However, the natural amenity ranking is estimated to be positively related to increased productivity over the period rather than increased attractiveness to households. Urban agglomeration is positively related to increased amenity attractiveness to households. Within Census regional analysis revealed a stronger role for household natural amenity demand in nonmetropolitan areas.

1. Introduction

From 1990 to 2000, the United States experienced the largest growth of population in its history. Population of metropolitan areas grew by 13.9 percent, while population within nonmetropolitan areas grew by 10.3 percent (Perry and Mackun, 2001). Yet, the pace of nonmetropolitan population growth fell by one-half in the last half of the 1990s, while metropolitan growth remained steady (Hamrick, 2002). The metropolitan-nonmetropolitan population growth gap continued post-2000, where nonmetropolitan population grew 4.5 percent from 2000-2010, less than one-half of the metropolitan rate of 10.8 percent (Kusmin, 2011). To be sure, nearly one-half of nonmetropolitan counties are estimated to have lost population from 1988-2008 through out-migration, in which more than one-third of the counties lost in excess of ten percent of their population (McGranahan et al. 2010).

Population growth is an important gauge of economic development because it reveals the relative attractiveness of places to households (Douglas, 1997; Hansen, 2001; Partridge and Rickman, 2003). Academic studies focus on both the roles of natural amenities and jobs in regional population growth (Graves, 1979; Greenwood and Hunt, 1989; Deller et al., 2001). In examining U.S. regional growth patterns, Partridge (2010) concludes that natural amenities better explain the observed patterns than New Economic Geography. In their assessment of utility levels across U.S. cities, Kemeny and Storper (2012) argue it is unlikely that natural amenities are an important determinant of inter-regional household location decisions. McGranahan et al. (2011) examine the interplay between outdoor amenities, entrepreneurial context and growth. Glaeser and Tobio (2008) highlight a third important factor underlying population growth in concluding that elastic housing supply was a more important growth determinant in the South the last half of the twentieth century than favorable weather.

Rickman and Rickman (2011) assess the changing role of natural amenity demand in nonmetropolitan county growth for 1990-2000, while accounting for the elasticity of housing supply and labor demand. They find household amenity demand as underlying stronger population growth in areas with higher levels of natural amenities. The roles of amenities, labor demand and the housing market in the cyclic dynamics of regional growth for nonmetropolitan and metropolitan portions of the U.S. states during the previous decade are examined by Rickman and Guettabi (2014). Natural amenities, labor demand and the housing regulatory environment all are concluded to have influenced expansions and contractions of state nonmetropolitan and metropolitan economies during the decade. Hertz et al. (2014) note the more favorable mix of industries in weathering the Great Recession in nonmetropolitan areas but note the effect of slower population growth on nonmetropolitan employment growth relative to metropolitan areas.

Therefore, using a spatial hedonic growth model this paper empirically assesses the relative roles of amenity demand, productivity and elasticity of housing supply in the variation of population growth across U.S. metropolitan and nonmetropolitan areas for 2000-2010. In contrast to previous applications of spatial hedonic growth models, the full geography of areas in the U.S. is considered, whereas, Glaeser and Tobio (2008) focus on the U.S. South and Rickman and Rickman (2011) focus solely on nonmetropolitan areas. We also examine growth differences across both the amenity hierarchy and the rural-urban continuum, and for the period 2000-2010. Finally, also in contrast to the previous studies, microdata are used to estimate the growth in labor earnings and housing costs rather than aggregate data.

Earnings and housing data are obtained from the IPUMS-USA database 2000 5% sample and the 2010 ACS 5-year sample and used along with population data aggregated to Public Use Microdata Areas (PUMAs) areas. The data are fitted to the spatial hedonic growth model where innovations to amenity demand, labor demand, and elasticity of housing supply are derived. Another contribution of the study is that not only are the innovations of amenity demand, productivity and land supply derived, multiplier expressions for each of the innovations implied by the theoretical spatial growth model are then used to decompose regional population growth into the parts attributable to each of the innovations.

The remainder of the paper is organized as follows. Section 2 presents the theoretical framework of the paper, including derivation of expressions for the innovations and multipliers. Section 3 describes the empirical implementation of the theoretical model. Section 4 presents and discusses the main findings for analysis of all areas together and for nonmetropolitan areas separately. Among the general findings is that natural amenities influenced regional growth, but primarily through its association with increased productivity. Similarly, rather than through influencing productivity, urban agglomeration, as measured by population, increased amenity attractiveness of the area to households. Within Census regions, however, household natural amenity demand primarily drove stronger population growth differences in areas with higher levels of natural amenities. Section 5 summarizes and concludes the paper.

2. Theoretical Framework

We use a spatial hedonic growth model (Glaeser and Tobio, 2008; Rickman and Rickman, 2011) that has its basis in the static spatial general equilibrium framework (Roback, 1982). In lieu of repeating the presentations of previous studies, we summarize the salient aspects of the model and present the expressions used in the empirical analysis.

The model contains two optimizing agents: the household and the firm. The household supplies labor and is assumed completely mobile across regions. Subject to a budget constraint, the household consumes a composite traded good with a normalized price of unity and housing (H) with price P_h to maximize utility. Amenities (A_h) serve as a utility shifter across regions. Utility of the household is assumed to be represented by the Cobb-Douglas constant-returns-to-scale function, with housing expenditure share α, and is equalized across regions because of perfect household mobility. The firm produces a nationally traded good, with normalized price equal to unity, according to a constant-returns-to-scale Cobb-Douglas function using labor (N), nationally mobile capital (K), and locally fixed capital (Z), with input expenditure shares equal to β, γ, and (1- β-γ), respectively. In addition, site-specific characteristics cause productivity (A_f) to vary regionally. The supply of housing is given by the fixed level of land (L) and housing structure (h) on the land. The cost per unit of land is P_l; the cost of housing structure is

$\xi_0 h^{\delta}$ where ξ_0 is a constant and δ>1. Free entry and zero economic profits are assumed in the housing sector in equilibrium.

In natural logarithms, the static equilibrium conditions for population (assuming full employment), wages (w) and housing prices from the above are as follows (Glaeser and Tobio, 2008; Rickman and Rickman, 2011):

$$\ln(N) = K_N + (\delta + \alpha - \alpha\delta)\ln\left(\boldsymbol{A}_f\right) + (1-\gamma)(\delta\ln(\boldsymbol{A}_h) + \alpha(\delta-1)\ln(L))/\Delta \quad (1)$$

$$\ln(w) = K_w + (\delta-1)\alpha\ln\left(\boldsymbol{A}_f\right) + (1-\beta-\gamma)(\delta\ln(\boldsymbol{A}_h) + \alpha(\delta-1)\ln(L))/\Delta \quad (2)$$

$$\ln(P_h) = K_H + (\delta-1)\ln\left(\boldsymbol{A}_f\right) + \beta\ln(\boldsymbol{A}_h) - (1-\beta-\gamma)\ln(L))/\Delta \quad (3)$$

where K_N, K_w and K_H are constant terms derived from the solutions and $\Delta = \delta(1-\beta-\gamma) + \alpha\beta(\delta-1)$.

To derive corresponding growth equations, unanticipated exogenous shocks to amenity demand, firm productivity and housing supply elasticity are added to equations (1) to (3) (Rickman and Rickman, 2011). Assuming that the static equilibrium conditions hold between periods t and t+1, equations (1) to (3) can be transformed into growth equations:

$$\ln(N_{t+1}/N_t) = £_N + \Delta^{-1}\left((\delta+\alpha-\alpha\delta)\lambda_f + (1-\gamma)(\delta\lambda_h + \alpha(\delta-1)\lambda_L)\right)\boldsymbol{R} + \varepsilon_N \quad (4)$$

$$\ln(w_{t+1}/w_t) = £_W + \Delta^{-1}\left((\delta-1)\alpha\lambda_f - (1-\beta-\gamma)(\delta\lambda_h + \alpha(\delta-1)\lambda_L)\right)\boldsymbol{R} + \varepsilon_W \quad (5)$$

$$\ln\left(P_{h,t+1}/P_{h,t}\right) = £_H + \Delta^{-1}\left((\delta-1)(\lambda_f + \beta\lambda_h - (1-\beta-\gamma)\lambda_L\right)\boldsymbol{R} + \varepsilon_H \quad (6)$$

where λ_f, λ_h and λ_L are the shocks to firm productivity, household amenity attractiveness and land supply common within regional category $\boldsymbol{R}$. The £ represent shocks common to all regions, while the ε represent shocks idiosyncratic to areas. $\boldsymbol{R}$ represents the South in Glaeser and Tobio (2008) and amenity classification in Rickman and Rickman (2011), where in this study it will represent classifications for both natural amenities and urban agglomeration.

Let $\boldsymbol{B_N}$, $\boldsymbol{B_W}$ and $\boldsymbol{B_H}$ represent the expressions multiplied by $\boldsymbol{R}$ in Equations (4) to (6), respectively. The expressions can then be solved simultaneously to obtain the innovations in productivity, amenity attractiveness and land supply. Productivity growth (λ_f) is revealed by (1-γ-β)$\mathbf{B_N}$+(1-γ)$\mathbf{B_W}$; strong population growth combined with wage growth is evidence of relative productivity gains. The change in amenity attractiveness (λ_h) then is obtained as ($\alpha\mathbf{B_H}$-$\mathbf{B_W}$); the negative of the decrease in real labor earnings reveals increased amenity attractiveness, which is consistent with the static equilibrium expression of Roback (1982). Relative growth in land supply (λ_L) is obtained as $\mathbf{B_N}$+ $\mathbf{B_W}$-($\delta\mathbf{B_H}$/(δ-1)); strong population and wage growth relative to housing price growth is evidence of increased elasticity of land supply.

To estimate the impacts of the shocks on growth, we derive the multiplier effects of the shocks on each of the three variables from Equations (4) to (6). A one percent change in amenity demand causes a $(1-\gamma)\delta\Delta^{-1}$ percent change in population, $-(1-\beta-\gamma)\delta\Delta^{-1}$ percent change in wages and $(\delta-1)\beta\Delta^{-1}$ percent change in housing prices, where Δ^{-1} equals to 1/ $\delta(1-\beta-\gamma)+\alpha\beta(\delta-1)$. A one percent change in productivity leads to a $(\delta+\alpha-\alpha\delta)\Delta^{-1}$ percent change in population, $(\delta-1)\alpha\Delta^{-1}$ percent change in nominal wages, and $(\delta-1)\Delta^{-1}$ percent change in housing costs. Finally, a one percent change of land supply causes a $\alpha(\delta-1)\Delta^{-1}$ percent change in population, $-\alpha(\delta-1)(1-\beta-\gamma)\Delta^{-1}$ percent change in wages and $-(\delta-1)(1-\beta-\gamma)\,\Delta^{-1}$ percent change in housing prices.

3. Data and Empirical Implementation

3.1 Data and Variable Measurement

Wages and housing costs are derived from the Integrated Public Use Microdata Series (IPUMS).[1] We use the Census 2000 5% sample and the American Community Survey 2006 to 2010 5-year sample. Because of their special locations, we exclude Alaska and Hawaii from the sample. To ensure that all workers are at working age and freely mobile, the workers are restricted to those of age ranging from 25 to 55 and not belonging to any group quarters and work at least 14 weeks per year and 20 hours per week. To mitigate the potential effects of reporting errors, we impose an additional criterion that the minimum salary should be $2,678 in 2000 5% sample and $3,770 in ACS 2006-2010 5-year sample.[2]

[1] IPUMS-USA website is https://usa.ipums.org/usa/.

[2] According to U.S. Department of Labor, the minimum wage rate under the Fair Labor Standards Act was $5.15 an hour beginning September 1, 1997 and increased to $7.25 for all covered, nonexempt workers since Jul 24, 2009. Thus, we use $5.15 times 20 hours times 26 weeks and $7.25 times 20 hours times 26 weeks to calculate the minimum wage for 2000 sample and 2010 sample accordingly. The source of minimum wage rate comes from http://www.dol.gov/whd/minwage/coverage.htm.

One of the advantages of using the 5% sample of Census 2000 and ACS 2006 to 2010 5-year samples is the smallest identifiable geographic unit is the Public Use Microdata Area (PUMA), containing at least 100,000 persons which give us the necessary degrees of freedom to statistically control for factors that may underlie regional differences in growth.[3] However, the Census Bureau redraws PUMA boundaries every ten years based on the most recent decennial census and ACS samples incorporate the new PUMAs within a few years of the decennial census. This problem makes the comparison more difficult for different time periods. To solve this problem, we select CONSPUMA as our calculation base. CONSPUMA is the code provided by IPUMS.[4] It identifies the most detailed geographic areas that can consistently be identified across samples from 1980 onwards. It splits the nation into 543 areas that can be consistently identified in microdata samples using PUMAs and County Groups. For separate analysis of nonmetro areas, we use the 2003 metro classification that can be obtained from the website Economic Research Service (ERS) of the United States Department of Agriculture (USDA).[5]

To make wages and housing costs comparable across states we calculate characteristic-adjusted wages and housing costs. We first perform an ordinary least squares regression of the natural logarithm of individual wages on fixed effects for CONSPUMAs, while controlling for characteristics of individuals. The basic regression equation is given by the following:

$$lnw_{ij} = \boldsymbol{\kappa X}_{ij} + \theta_j + \varepsilon_{ij} \qquad (7)$$

where lnw_{ij} is the natural log wage of individual i in CONSPUMA j. $\boldsymbol{X}_{ij}$represents the vector of characteristics of individual i in area j. θ_j is the fixed effect of area j. ε_{ij} is the error term.

We control for several individual characteristics in the regression. Firstly, we include age interval indicators: ages 31 to 35, 36 to 40, 41 to 45, 46 to 50, and 51 to 55, to capture age and experience wage effects. The age interval from 25 to 30 is omitted to avoid perfect collinearity.

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[3] According to the description of IPUMA-USA database, counties are unavailable in public-use microdata from 1950 onwards.

[4] Although according to the description of IPUMS, the boundaries and PUMA codes are the same for the 2000 census and the 2006-2011 ACS/PRCS samples. However, due to population displacement following Hurricane Katrina, one notable exception in Louisiana: three PUMA's (01801, 01802, and 01905) are combined into code 77777 for the 2006-onward ACS and for all cases in the 2005-2007 ACS 3-Year file.

[5] Economic Research Service of the United States Department of Agriculture website: http://www.ers.usda.gov/.

Secondly, we add several dummy variables to capture the impacts of different education levels: grade 10, grade 11, grade 12, 1 year of college, 2 years of college and 4 years of college, where category grade 9 and below is omitted from the regression to avoid perfect collinearity. To remove errors and extreme outliers, we restrict the sample by eliminating the individuals that report education levels below grade 4.

Thirdly, we control for weeks and hours worked: 1) working 27 to 39 weeks, 40 to 47 weeks, 48 to 49 weeks, over 50 weeks;[6] 2) working 30 to 34 hours per week, 35-39 hours, 40 hours 41-48 hours, 49 to 59 hours and working over 60 hours per week. We omit those reporting working weeks from 14 to 26 and reporting working hours from 20 to 29 hours per week.

Furthermore, we control for race using binary indicators of Hispanic origin, Black or African American, Asian and other nonwhite, where the category of white is omitted. In addition, binary indicators are included for married, having a child, having a child below age of 5, speaking English at home, poor level of English proficiency, veteran status and immigration status may also impact individuals' employment and salaries.

Finally, we include industry and occupation controls in the regression. Based on the IND1990 code, the industries for which indicators are specified include: agriculture, forestry and fisheries; mining; construction; manufacturing; transportation, communications and other public utilities; wholesale trade; retail trade; finance, insurance and real estate; business and repair services; personal services; entertainment and recreation services; professional and related services; and public administration, with active duty military the omitted category. The vector of occupation indicators based on OCC1990 code include: managerial and professional specialty occupations; technical, sales and administrative support occupations; service occupations; farming; forestry and fishing occupations; precision production; craft and repair occupations and operators; and fabricators and laborers. Military is the omitted category.

[6] The intervals of the weeks worked last year are given by ACS. After 2007, there is no other information about the weeks worked last year except these intervals.

The baseline characteristic-adjusted wages can be obtained as $ln\widehat{w}_j = \widehat{\boldsymbol{\kappa}}\overline{\boldsymbol{X}} + \hat{\theta}_j$ where $ln\widehat{w}_j$ represents baseline characteristics adjusted wages in area j. $(\widehat{\boldsymbol{\kappa}}\overline{\boldsymbol{X}} + \hat{\theta}_j)$ is predicted average wage whereas $\overline{\boldsymbol{X}}$ represents the national mean of characteristics for individuals. We run regressions separately for males and females to capture labor market differences between them:

$$ln\widehat{w}_j = \omega\, ln\widehat{w}_j^m + (1-\omega) ln\widehat{w}_j^f \qquad (8)$$

where ω represents the proportion of males in the sample, while $(1-\omega)$ is the proportion of females in the sample. $ln\widehat{w}_j^m$ means the baseline characteristics adjusted wages of male; $ln\widehat{w}_j^f$ represents the baseline characteristics adjusted wages of female.

Housing costs refers to housing rents or a housing-price-based imputed rent for homeowners plus the costs of utilities, water, electricity, gas, and the costs of fuel, oil, coal, kerosene, wood, etc. Following previous studies (Beeson and Eberts, 1989; Blomquist et al., 1988; Gabriel and Rosenthal, 2004; Partridge et al., 2010), we convert owner-occupied median housing prices into imputed annual rent using a discount rate of 7.85% by Peiser and Smith (1985). The basic housing regression is given by the following:

$$lnh_{ij} = \boldsymbol{\varphi}\boldsymbol{Z}_{ij} + \eta_j + \mu_{ij} \qquad (9)$$

where lnh_{ij} is natural log of housing cost for individual i in CONSPUMA area j. $\boldsymbol{Z}_{ij}$ represents the vector of house characteristics, which include whether housing units contain a business on the property, located on over 10 acres, number of rooms indicators of 2-4 rooms, 5-8 rooms and over 9 rooms, while the 1 room category is omitted. Also included are whether the residence contained complete plumbing facilities, whether it contained kitchen facilities, the bedroom-to-room ratio, and age of the structure. For the age of the structure, we include binary indicators of 2-5 years, 6-10 years, 11-20 years, 21-30 years, 31-40 years, 41-50 years and over 50 years in the 2000 sample; and whether the structure was built in 2000-2004, 1990-1999, 1970-1989, 1940-1969 and earlier than 1940 as indicators in the 2005-2010 ACS sample. The category of 1 year old and whether the structure was built after 2005 are omitted for 2000 sample and 2010 sample, respectively. η_j is the fixed effect of CONSPUMA j and μ_{ij} is the error term.

We run the regression for home owners and renters separately to obtain the estimated housing owner cost, $ln\hat{h}_j^o = \boldsymbol{\varphi}\bar{\boldsymbol{Z}}^o + \hat{\eta}_j^o$, and rental housing cost, $ln\hat{h}_j^r = \boldsymbol{\varphi}\bar{\boldsymbol{Z}}^r + \hat{\eta}_j^r$. We combine the two estimates to obtain the weighted housing cost of each CONSPUMA j as follows

$$ln\hat{h}_j = \tau\, ln\hat{h}_j^o + (1-\tau)ln\hat{h}_j^r \qquad (10)$$

where $ln\hat{h}_j$ denotes baseline characteristics-adjusted housing cost in area j. τ is the percent of a house unit owned by household; $(1-\tau)$ is the percent of rented housing units.

Population is from the Decennial Censuses of Population and Housing of the U.S. Bureau of the Census.[7] We obtain population of CONSPUMAs by summing the population of the counties in each CONSPUMA. Table 1 presents the descriptive statistics for population, wages and housing costs.

3.2 Empirical Model

We implement Equations (4) to (6) using natural log-differences in population, wages and housing costs between years 2000 and 2010. $\boldsymbol{R}$ is measured by region classification codes produced by Economic Research Service (ERS) of the United States Department of Agriculture for natural amenity attractiveness and position along the rural-urban continuum. The codes, provided at the county level, are weighted by county population shares in each CONSPUMA based on the Census Bureau April 1, 2000 estimates.

$$\ln(pop_{2010}/pop_{2000}) = \rho_N + \boldsymbol{B_N R} + \boldsymbol{\theta Control} + \varepsilon_N \qquad (11)$$

$$\ln(wage_{2010}/wage_{2000}) = \rho_W + \boldsymbol{B_W R} + \boldsymbol{\theta Control} + \varepsilon_W \qquad (12)$$

$$\ln(hous_{2010}/hous_{2000}) = \rho_H + \boldsymbol{B_H R} + \boldsymbol{\theta Control} + \varepsilon_H \qquad (13)$$

where ρ_N, ρ_W and ρ_H are constants. $\boldsymbol{B_N}$, $\boldsymbol{B_W}$ and $\boldsymbol{B_H}$ are the coefficient vectors of binary indicator variables to be estimated. ε_N, ε_W and ε_H are error terms.

The first set of binary indicators represents the ERS natural amenity ranking.[8] The amenity ranking is based on the natural amenity scale composed by the combination of six

[7] The source of county-level population comes from the U.S. Bureau of the Census website: http://www.census.gov/popest/data/intercensal/index.html

[8] The analysis for only nonmetropolitan areas also includes nonmetropolitan recreation county indicator by the USDA Economic Research Services as the indicator of natural amenity measurement.

measures: average January temperature, average January days of sun, average July temperature, average July humidity, topographic variation and water area-to-county area ratio (McGranahan, 1999). To obtain CONSPUMA amenity rankings, we calculate population-weighted ERS amenity scale values and then assign amenity ranks consistent with the method used by ERS: 7 for CONSPUMAs with weighted amenity scale values greater than 3; 6 for values between 2 and 3; 5 for values between 1 and 2; 4 for values between 0 and 1; 3 for values between 0 and -1; 2 for values between -1 and -2; and 1 for scale values lower than -2. We then include a vector of indicator variables for the amenity ranks, where rank 1 is the omitted category.

The second set of binary indicators is derived from the CONSPUMA's position along the rural-urban continuum. The rural-urban continuum codes are based on the 2003 USDA Economic Research Service's nine category codes. The codes range from one to nine, denoting whether a county is: 1) in a metropolitan area with population of 1 million or more; 2) in a metropolitan area of 250,000 to 1 million people; 3) in a metropolitan area with population fewer than 250,000; 4) a nonmetropolitan county with urban population of 20,000 or more , and adjacent to a metropolitan area; 5) a nonmetropolitan county with urban population of 20,000 or more, but not adjacent to a metropolitan area; 6) a nonmetropolitan county with urban population of 2,500 to 19,999, adjacent to a metropolitan area; 7) a nonmetropolitan county with urban population of 2,500 to 19,999, not adjacent to a metropolitan area; 8) a nonmetropolitan county completely rural or less than 2,500 urban population, adjacent to metropolitan area; or 9) a nonmetropolitan county completely rural or less than 2,500 urban population, not adjacent to metropolitan area. Similar to the amenity attractiveness variable, to obtain CONSPUMA-level indicator variables, we use indicators for ranges of values: [1,2), [2,3), [3,4), [4,5), [5,6), and [6,7), where [indicates the lower value is included in the range and) indicates the upper value is not included; the category [7, 9) is the omitted category.[9]

[9] Because there are too few observations in category [8, 9), we merge categories [8, 9) and [7, 8) to create a category where the rank is greater than or equal to 7.

Industry composition variables based on the classification by ERS are included as control variables ($\boldsymbol{Control}$). The variables represent whether the area is primarily dependent on: farming, mining, manufacturing, federal or state government, or services. Sectorally-diversified areas are the omitted category. Similar to the other variables listed above, the industry composition variables are weighted by the population to obtain CONSPUMA-level data. The weighted-industry composition variables indicate the proportion of counties dependent on each industry in the CONSPUMA.

4. Findings and Discussion

4.1 Regression Results

Tables 2 and 3 display the regression results for estimation of Equations (11) to (13). Table 2 shows the results for all areas, while Table 3 displays the results from estimating the equations for nonmetropolitan CONSPUMAs separately. Columns (1) to (3) of each table show the results for a model only including the amenity variables, while Columns (4) to (6) show the results after adding the rural-urban continuum indicator variables. Columns (7) to (9) contain the results for the full model, obtained after adding industry composition variables to the model.

From the first three columns of Table 2, it can be seen that the growth of population was generally positively related to increasing area amenities, except for the first two ranks just above the omitted category. Wage and housing price growth generally increased with amenity ranking. Columns (4) to (6) show that after adding the rural-urban continuum code variables, amenity attractiveness exhibited the same patterns compared to the columns (1) to (3) results. In general, the higher the rank of the area in the rural-urban continuum, the faster was its population growth during the period of 2000 to 2010. Fastest growth occurred in CONSPUMAs with metropolitan areas containing population less than one million. No significant effects are shown for wage growth. Housing price growth was fastest in CONSPUMAs containing the largest metropolitan areas. A couple of the nonmetropolitan categories did not experience differential housing price growth relative to the omitted category, the smallest areas.

The last three columns of Table 2 show the results of using the full model obtained after adding industry dependency variables. The amenity variables exhibited fairly much the same pattern as in the results for the two previous models in columns (1) to (6). The patterns across the rural-urban continuum also are not much affected by including the industry dependency variables. Relative to industry diversified areas, population, wages and housing costs declined in manufacturing dependent areas from 2000 to 2010. Energy and services dependent areas experienced relative declines in population and housing costs. No significant relative growth effects were found for farm or government dependent areas.

The results from only examining the nonmetropolitan CONSPUMAs are presented in Table 3. We focus our discussion on a comparison of the nonmetropolitan results for the full model in columns (7) to (9) with the corresponding results in Table 2. The nonmetropolitan population amenity growth results are fairly comparable to those for all areas, except that growth was fairly even across all three top tiers of the amenity hierarchy, consistent with the pattern for 1990-2000 (Rickman and Rickman, 2011). In contrast to the full model results for all areas, the amenity rank variables are insignificant in the nonmetropolitan wage growth regression. Only three of the amenity rank variables are significant in the nonmetropolitan housing cost regression, where the top amenity tier areas experienced significant stronger growth than those in the next two tiers below.

There are few growth differences across the rural-urban continuum for nonmetropolitan areas. As for all areas, there are not any significant wage growth effects across the continuum, while there are significantly higher housing cost growth rates for more populated nonmetropolitan areas. In contrast to the results for all areas, there also are not any significant population growth differences for nonmetropolitan areas in terms of their population levels and remoteness as measured by the rural-urban continuum code. Areas dependent on services experienced faster population and housing cost growth, where some of the negative growth effects remain for manufacturing and energy and there now are estimated negative housing and population growth effects for farm dependent regions.

4.2 Growth Decomposition

To assess the underlying sources of growth differences in population, wages and housing costs, we next apply the expressions derived from the theoretical model to the regression results. Firstly, we apply the expressions for deriving the innovations in household attractiveness, productivity and land supply to the coefficients obtained for the amenity hierarchy and rural-urban continuum binary indicator variables. Secondly, we combine the estimated innovations with derived expressions for corresponding multiplier effects to obtain the effects of the innovations on growth in population, wages and housing costs.

Recall that relative innovations in amenity attractiveness, λ_h, are revealed by the negative of the change in real wages: $(\alpha \boldsymbol{B_H} - \boldsymbol{B_W})$. Weighted changes in population and wage growth reveal the relative innovations in productivity growth, λ_f: $((1-\beta-\gamma)\boldsymbol{B_N} - (1-\gamma)\boldsymbol{B_W})$. Finally, relative innovations in land supply, λ_L, can be derived from population and wage growth relative to weighted land supply growth: $(\boldsymbol{B_N} + \boldsymbol{B_W} - (\delta \boldsymbol{B_H}/(\delta - 1))$. We use the following values for the parameters (Glaeser and Tobio, 2008): the housing expenditure share, α, is set equal to 0.3; the Cobb-Douglas production shares for labor (γ) and capital (β) are set equal to 0.6 and 0.3, respectively; the elasticity of housing supply (δ) is set equal to 1.5.[10]

Panel A of Table 4 shows the growth innovations of amenity demand, productivity and land supply from 2000 to 2010. Columns (1) to (3) display the innovation decomposition across both metropolitan and nonmetropolitan areas using the Table 2 coefficients from the full model. Columns (4) to (6) show the decomposition across only nonmetropolitan areas using the Table 3 coefficients from the full model. For the entire sample and for nonmetropolitan areas separately, larger productivity innovations occurred further up the amenity hierarchy, while negative innovations in land supply were greatest in the highest amenity tier. The strong productivity effect is consistent with productive firms or individuals with unobserved highly productive skills

[10] The results are robust to reasonable changes in the parameters. For example, increasing the household expenditure share on housing by twenty percent to 0.36 to capture the positive correlation between local housing prices and other nontraded goods prices (Shapiro, 2006) only makes natural amenity demand a slightly more important determinant of population growth and the dominant qualitative patterns remain intact.

(McGranahan and Wojan, 2007; Lee, 2010) disproportionately locating in high amenity areas. Only for nonmetropolitan areas, are the innovations in household amenity demand the (slightly) largest positive innovation for the top amenity tier areas. Negative relative innovations in amenity demand in higher amenity areas can arise from negative growth effects from other sources on the attractiveness of the areas to households (Gabriel et al., 2003).

As shown in columns (1) to (3) of Panel B in Table 4, the largest metropolitan areas had the largest innovations in amenity demand and most negative innovations in land supply. The large innovations in amenity demand in the largest metropolitan areas are consistent with the consumer city hypothesis of Glaeser et al. (2001). Perhaps surprisingly, innovations in productivity were not much greater in metropolitan areas. From columns (4) to (6), amenity demand was stronger in the more populated nonmetropolitan areas. Productivity was highest in the code range of 6-7 relative to the omitted category, while innovations in land supply were most negative in the ranges 5-6 and 6-7.

To assess the impacts of the innovations, we next multiply the innovations by estimated multipliers from the theoretical model. The parameter values from the theoretical model used to derive the innovations also are used to estimate the multipliers. The results for all areas are presented in Table 5, while those for nonmetropolitan areas separately are presented in Table 6. The ratios of the growth effects to the innovations reveal the magnitudes of the multipliers.

Columns (1) to (3) in each table display the impacts of amenity demand changes on population, wages and housing prices, respectively. Columns (4) to (6) show the changes in population, wages and housing prices caused by productivity shocks accordingly. Columns (7) to (9) report the changes caused by elasticity of housing supply shocks in population, wages and housing prices, respectively.

Panel A of Table 5 shows that not only did productivity positively influence population growth in the highest two tiers of amenity areas, the multiplier effects of the innovations in productivity were large. The positive productivity effects dominate the negative household amenity and land supply effects in the higher tiered areas to produce overall stronger population growth. In the highest amenity-ranked areas, the negative change in amenity attractiveness, the positive increase in productivity, and more inelastic land supply all contributed to rising wages, where the productivity effects were approximately double each of the other two effects.

Panel B of Table 5 shows that the stronger population growth of the largest metropolitan areas was mostly driven by increased household amenity attractiveness, with the positive productivity effect having slightly more than one-half the effect. Increased inelasticity of land supply significantly reduced growth, by an amount that more than offsets the positive productivity effects. For areas with codes between 2 and 3, increased amenity demand and increased productivity had approximately equal effects on population growth, while land supply had little influence. Increased amenity demand put downward pressure on wages, while increased productivity and more inelastic land supply pushed wages upwards, producing the insignificant changes in relative wages in metropolitan areas generally. Increased productivity growth drove the faster population growth in larger nonmetropolitan areas.

For the sample of nonmetropolitan areas only, as shown in Panel A of Table 6, increased productivity growth continued to be the dominant source of population growth in the highest tier amenity areas, though increased amenity attractiveness also led to stronger population growth, with the effect about one-half the size of the productivity effect. Increased relative inelasticity of land supply approximately offset the positive household amenity effect in these areas. The next two highest ranked amenity areas also experienced strongest population growth from increased productivity growth, with positive but much less than half the effects by increased amenity attractiveness. Land supply did not become more relatively inelastic in these areas.

Increased household amenity attractiveness of the highest amenity tier areas reduced relative wage growth, but this was more than offset by the positive wage growth effects of increased productivity and relatively more inelastic land supply. Increased productivity and more inelastic land supply were equally responsible for the strongest growth of housing prices in the highest amenity tier areas.

From Panel B of Table 6, we see that productivity growth underpinned the stronger population growth in the largest nonmetropolitan areas. This is consistent with Partridge et al. (2010) who found slower growth during the 1990s in more remote nonmetropolitan areas to be underpinned by lower productivity growth. Codes 5-7 also grew because of increased amenity attractiveness relative to the smallest nonmetropolitan areas. The relative increased inelasticity of land supply inhibited population growth the most in areas with codes in the range of 5-6.

4.3 Sensitivity Analysis

Clark et al. (2003) suggest that regional economies may not be in equilibrium at any given point in time in finding that net in-migration occurred in areas where there was estimated over-compensation and away from areas where there was under-compensation. Estimates of over- and under-compensation are obtained in the study as residuals from hedonic estimation in levels. Therefore, in sensitivity analysis we estimate hedonic wage and housing cost equations (i.e., Equations (7) and (9)) for year 2000 and include residuals from the levels equations in the growth equations (11-13).[11] The growth decomposition results associated with the new regression results are shown in Tables 7 and 8.

The results for all areas, both metropolitan and nonmetropolitan, are shown in Table 7. The primary difference in amenity results from Panel A of Table 5 is that now increased amenity demand is estimated to have dramatically increased population growth in the top amenity-ranked areas. However, increased productivity growth still had more than double the amenity effect. Land supply is now estimated to have become even more relatively inelastic in the top amenity tier areas. From Panel B of Table 7, we see that the relative amenity demand effect does not diminish as dramatically in moving to areas lower in the urban hierarchy. Land supply is now estimated to have not become as relatively inelastic in the largest metropolitan areas compared to

[11] Both the wage and housing cost residuals are included in the population growth equation, where only the wage residuals are included in the wage growth equation and only the housing cost residuals are included in the housing cost growth equation. In results not shown, the wage residuals variable is significant in both the population and wage growth equations. The housing cost residuals variable is only significant in the housing cost growth equation.

all other areas, though most areas appear increasingly inelastic compared to the smallest omitted areas.

The growth decomposition sensitivity analysis results for nonmetropolitan areas are shown in Table 8. Panel A shows much stronger relative population growth effects from both increased amenity demand and productivity in the top amenity tier areas, where increased relative amenity demand is now estimated to be slightly more important than relative productivity growth. Land supply is now estimated to have become even more slightly inelastic relative to Table 6. Strong productivity growth remains as the most important growth determinant in areas with amenity ranks between 4 and 6. For the rural-urban continuum, the omitted category of the smallest nonmetropolitan areas is now estimated to be much less amenity attractive and not as relatively unproductive. Only in the areas with average code between 4 and 5 is productivity estimated to have increased relative to the most rural and remote areas.

In further sensitivity analysis, because natural amenity migration may be more prevalent within major regions than between them (Kemeny and Storper, 2012) we re-estimated the full model growth equations after adding indictor variables for Census regions, omitting the Northeast region. For the sample including both metropolitan and nonmetropolitan areas (Table 9), the top natural amenity tier areas now are estimated to be household attractive, but the productivity effect on population growth is still more than double the natural amenity effect. The estimated population growth productivity advantages in more populated areas are more muted. For nonmetropolitan areas (Table 10), the household natural amenity effect becomes the dominant factor in explaining stronger population growth in areas with higher levels of natural amenities, consistent with greater natural amenity sorting within major Census regions than between them. Productivity effects on population growth are no longer positively correlated with the natural amenity ranking.

Finally, we also reran the first stage wage regression (Equation 7) after omitting the industry and occupation control variables. In results not shown, the growth decompositions shown in Tables 5 and 6 were not noticeably affected, with all patterns remaining intact and only slight quantitative changes. This suggests an absence of sorting on observed industries and occupations that would affect our results.

5. Conclusion

This paper examines the patterns in U.S. regional population growth during the period of 2000-2010 within the context of a spatial equilibrium model (Glaeser and Tobio, 2008; Rickman and Rickman, 2011). Variation in population growth is examined across the natural amenity spectrum and the rural-urban continuum, and decomposed into the portions attributable to relative changes in household amenity demand, productivity, and elasticity of land supply. Regions are defined by consistent Public Use Microdata Areas and include both metropolitan and nonmetropolitan areas.

The results suggest that understanding regional growth differences is not as simple as determining the relative importance of household natural amenity migration versus urban agglomeration economies. On average, across both metropolitan and nonmetropolitan areas, variation in productivity dominated in terms of explaining the differences in population growth across the natural amenity spectrum. This suggests that natural amenities attracted firms more than households or that those households possessing unmeasured highly productive attributes sorted (Lee, 2010) into high natural amenity areas. It was for larger metropolitan areas where amenity attractiveness to households dominated productivity growth in explaining population growth patterns. So, rather than agglomeration economies producing jobs that cause in-migration, it is the attractiveness of cities to households that appeared to spur population growth (Glaeser et al., 2001).

While focusing solely on the growth patterns across nonmetropolitan areas, we found that increased amenity demand in natural amenity attractive areas spurred their growth, although productivity effects continued to be the most important growth determinants across the natural amenity spectrum. As the spatial equilibrium growth model predicted, increasing demand for natural amenities caused higher growth rates in population that increased housing prices, while also pushing downwards on the growth of wages. Although the highest amenity rank areas experienced the strongest increase in amenity demand and productivity growth, it also had the most inelastic change in land supply, limiting population growth relative to that in the next two lower amenity tiers. Only within major Census regions for nonmetropolitan areas was natural amenity migration the dominant factor underlying regional population growth patterns. Controlling for pre-existing disequilibrium in the labor and housing markets also increased the estimated role of natural amenity migration in regional growth patterns.

Finally, the convergence of nonmetropolitan population growth across the top three amenity tiers during 2000-2010 then may not only be related to the capitalization of natural amenity differences into wages and land rents or convergence in overall quality of life as suggested for the 1990s by Rickman and Rickman (2011). Rather, the convergence also appears attributable to exogenous changes that made land relatively more inelastic in these areas over the decade. This does not necessarily suggest, however, that high amenity nonmetropolitan areas should strive to make land more available, as population growth can impose additional limitations on itself through negative feedback effects on quality of life (Gabriel et al., 2003; Rickman and Rickman, 2011).

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Table 1. Statistics Table for Population, Wages and Housing Costs (natural logarithms)

	Mean	
Variables	All Areas	Nonmetro
population 2000	12.86	12.24
	(0.927)	(0.771)
wages 2000	10.24	10.05
	(0.134)	(0.0673)
housing 2000	7.290	7.271
	(0.196)	(0.124)
population 2010	12.93	12.28
	(0.932)	(0.775)
wages 2010	10.50	10.32
	(0.136)	(0.0684)
housing 2010	7.630	7.539
	(0.267)	(0.159)
population change 2000-2010	0.0755	0.0382
	(0.0964)	(0.0641)
wages change 2000-2010	0.264	0.265
	(0.0400)	(0.0308)
housing change 2000-2010	0.340	0.267
	(0.110)	(0.0698)
Observations	539	153

Standard Deviation in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2. Growth Regression Results across All Areas 2000-2010

	population	wages	housing	population	wages	housing	population	wages	housing
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Amenity rank 2	-0.0383***	-0.0103	-0.00622	-0.0317***	-0.0119*	-0.0249*	-0.0306***	-0.0107*	-0.0250**
	(-3.487)	(-1.421)	(-0.452)	(-2.839)	(-1.653)	(-1.883)	(-2.778)	(-1.712)	(-1.978)
Amenity rank 3	0.00167	0.0224***	0.0427***	0.00457	0.0222***	0.0356***	0.00572	0.0175***	0.0274**
	(0.159)	(4.038)	(3.285)	(0.449)	(4.023)	(2.979)	(0.555)	(3.417)	(2.385)
Amenity rank 4	0.0266**	0.0374***	0.0843***	0.0272**	0.0371***	0.0709***	0.0236*	0.0262***	0.0489***
	(2.162)	(6.530)	(5.709)	(2.219)	(6.571)	(5.521)	(1.897)	(4.888)	(3.826)
Amenity rank 5	0.0487***	0.0304***	0.0749***	0.0479***	0.0306***	0.0621***	0.0423***	0.0171***	0.0352**
	(3.080)	(4.886)	(4.138)	(3.070)	(5.027)	(4.133)	(2.734)	(2.900)	(2.380)
Amenity rank 6	0.0962***	0.0436***	0.0712***	0.0931***	0.0445***	0.0791***	0.0902***	0.0269***	0.0351**
	(5.072)	(5.733)	(4.382)	(4.863)	(5.736)	(4.679)	(4.670)	(3.491)	(2.174)
Amenity rank 7	0.0967***	0.0498***	0.132***	0.0917***	0.0507***	0.116***	0.0881***	0.0348***	0.0797***
	(7.403)	(8.854)	(9.359)	(7.167)	(9.123)	(8.362)	(6.603)	(6.182)	(5.422)
rururb 1 - 2				0.0574***	-0.00803	0.112***	0.0616***	-0.000464	0.0825***
				(3.881)	(-0.854)	(6.343)	(3.743)	(-0.0525)	(5.038)
rururb 2 - 3				0.0751***	-0.0141	0.0387**	0.0763***	-0.00506	0.0230
				(4.930)	(-1.480)	(2.291)	(4.879)	(-0.571)	(1.490)
rururb 3 - 4				0.0617***	-0.00722	0.0334**	0.0654***	0.00527	0.0277*
				(4.164)	(-0.756)	(2.035)	(4.274)	(0.593)	(1.840)
rururb 4 - 5				0.0467***	-0.00949	0.0220	0.0464***	0.00349	0.0236*
				(3.048)	(-0.954)	(1.366)	(2.927)	(0.388)	(1.694)
rururb 5 - 6				0.0269*	0.000816	0.0367*	0.0214	0.00818	0.0384**
				(1.727)	(0.0767)	(1.960)	(1.403)	(0.856)	(2.423)
rururb 6 - 7				0.00608	0.00158	0.0209	-0.00408	0.00289	0.0152
				(0.370)	(0.138)	(1.072)	(-0.252)	(0.287)	(0.958)
farm county							0.0321	0.0259	-0.0716
							(0.999)	(1.561)	(-1.473)
energy county							-0.107***	-0.00683	-0.123***
							(-2.730)	(-0.332)	(-3.477)
manufacturing county							-0.0354***	-0.0408***	-0.0720***
							(-2.708)	(-9.104)	(-5.426)
government county							-0.0261	0.00722	0.0272
							(-1.552)	(1.126)	(1.521)
services county							-0.0344**	-0.00564	0.0331**
							(-2.407)	(-1.346)	(2.123)
Constant	0.0510***	0.240***	0.284***	-0.00556	0.249***	0.234***	0.0186	0.259***	0.275***
	(6.737)	(49.76)	(31.41)	(-0.370)	(24.43)	(13.78)	(1.136)	(27.46)	(16.92)
Observations	539	539	539	539	539	539	539	539	539
R-squared	0.208	0.259	0.175	0.243	0.270	0.296	0.263	0.401	0.392

Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3. Growth Regression Results across Nonmetro Areas 2000-2010

	population	wages	housing	population	wages	housing	population	wages	housing
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Amenity rank 2	-0.000513	-0.00190	0.00472	-0.000564	-0.00387	0.00884	-0.00360	-0.0122	-0.00800
	(-0.0413)	(-0.194)	(0.443)	(-0.0455)	(-0.391)	(0.769)	(-0.284)	(-1.494)	(-0.747)
Amenity rank 3	0.0147	0.00413	0.0359**	0.0167	0.00406	0.0357**	0.0124	-0.00153	0.0223*
	(1.156)	(0.492)	(2.520)	(1.367)	(0.488)	(2.451)	(0.920)	(-0.227)	(1.797)
Amenity rank 4	0.0565***	0.0145*	0.0466***	0.0567***	0.0140*	0.0462***	0.0523***	0.00425	0.0304***
	(4.164)	(1.687)	(3.962)	(4.297)	(1.666)	(3.923)	(4.135)	(0.639)	(2.920)
Amenity rank 5	0.0952***	0.0126	0.0213*	0.0903***	0.0129	0.0171	0.0892***	-0.00580	-0.00419
	(6.043)	(1.328)	(1.735)	(5.386)	(1.386)	(1.315)	(5.223)	(-0.731)	(-0.281)
Amenity rank 6	0.105***	0.0166	0.0636***	0.107***	0.0166	0.0620***	0.0947***	0.000619	0.0219
	(6.224)	(1.499)	(4.349)	(6.293)	(1.467)	(3.995)	(6.203)	(0.0673)	(1.507)
Amenity rank 7	0.102***	0.0336***	0.123***	0.0987***	0.0345***	0.116***	0.0957***	0.0102	0.0839***
	(6.591)	(2.986)	(4.299)	(6.265)	(2.975)	(4.122)	(5.179)	(1.006)	(2.906)
rururb 4 - 5				0.0337**	-0.00507	0.0277	0.0222	0.0119	0.0306**
				(2.082)	(-0.504)	(1.598)	(1.340)	(1.407)	(2.032)
rururb 5 - 6				0.0129	-0.0103	0.0285**	0.00327	0.00155	0.0260*
				(1.078)	(-1.206)	(2.095)	(0.269)	(0.197)	(1.935)
rururb 6 - 7				0.0146	-0.00843	0.0127	0.00865	0.000907	0.0149
				(1.166)	(-0.988)	(0.964)	(0.718)	(0.119)	(1.204)
farm county							-0.0531*	0.0127	-0.106***
							(-1.738)	(0.677)	(-2.925)
energy county							-0.0441	-0.00437	-0.0998***
							(-1.331)	(-0.299)	(-3.095)
manufacturing county							0.00486	-0.0506***	-0.0668***
							(0.221)	(-6.698)	(-2.822)
government county							0.0177	0.0128	0.0285
							(0.781)	(0.989)	(0.897)
services county							0.0800**	-0.00310	0.0906**
							(2.249)	(-0.206)	(2.317)
Constant	-0.00369	0.256***	0.230***	-0.0192	0.263***	0.211***	-0.0125	0.278***	0.251***
	(-0.416)	(36.39)	(34.26)	(-1.459)	(25.87)	(16.91)	(-0.683)	(31.40)	(13.80)
Observations	153	153	153	153	153	153	153	153	153
R-squared	0.402	0.112	0.237	0.425	0.124	0.258	0.490	0.384	0.453

Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4. Growth Component Analysis from 2000 - 2010 (in Log-Point Changes)

	Metropolitan and Nonmetropolitan Areas			Nonmetropolitan Areas		
	Amenity Demand	Productivity Growth	Housing Supply	Amenity Demand	Productivity Growth	Housing Supply
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Innovations across the Amenity Hierarchy						
Amenity rank 2	0.003	-0.007	0.034	0.010	-0.005	0.008
Amenity rank 3	-0.009	0.008	-0.059	0.008	0.001	-0.056
Amenity rank 4	-0.012	0.013	-0.097	0.005	0.007	-0.035
Amenity rank 5	-0.007	0.011	-0.046	0.005	0.007	0.096
Amenity rank 6	-0.016	0.020	0.012	0.006	0.010	0.030
Amenity rank 7	-0.011	0.023	-0.116	0.015	0.014	-0.146
Panel B: Innovations across the Rural-Urban Continuum						
Code 1-2	0.025	0.006	-0.186			
Code 2-3	0.012	0.006	0.002			
Code 3-4	0.003	0.009	-0.012			
Code 4-5	0.004	0.006	-0.021	0.010	-0.005	0.008
Code 5-6	0.003	0.005	-0.086	0.008	0.001	-0.056
Code 6-7	0.002	0.001	-0.047	0.005	0.007	-0.035

Table 5. Growth Decomposition across Metropolitan and Nonmetropolitan Areas 2000 – 2010 (in Log-Point Changes)

	Amenity Demand			Productivity			Elasticity of Housing Supply		
	Pop	Wage	Housing	Pop	Wage	Housing	Pop	Wage	Housing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Growth Decomposition across the Amenity Hierarchy									
Amenity rank 2	0.010	-0.002	0.002	-0.051	-0.006	-0.019	0.010	-0.003	-0.009
Amenity rank 3	-0.029	0.007	-0.007	0.052	0.006	0.019	-0.018	0.005	0.015
Amenity rank 4	-0.035	0.009	-0.009	0.089	0.010	0.033	-0.030	0.007	0.025
Amenity rank 5	-0.020	0.005	-0.005	0.077	0.009	0.028	-0.014	0.004	0.012
Amenity rank 6	-0.050	0.013	-0.013	0.137	0.015	0.051	0.004	-0.001	-0.003
Amenity rank 7	-0.034	0.008	-0.008	0.157	0.017	0.058	-0.036	0.009	0.030
Panel B: Growth Decomposition across the Rural-Urban Continuum									
Code 1-2	0.078	-0.019	0.019	0.041	0.005	0.015	-0.057	0.014	0.048
Code 2-3	0.037	-0.009	0.009	0.039	0.004	0.014	0.001	0.000	-0.001
Code 3-4	0.009	-0.002	0.002	0.060	0.007	0.022	-0.004	0.001	0.003
Code 4-5	0.011	-0.003	0.003	0.042	0.005	0.015	-0.006	0.002	0.005
Code 5-6	0.010	-0.003	0.003	0.037	0.004	0.014	-0.026	0.007	0.022
Code 6-7	0.005	-0.001	0.001	0.005	0.001	0.002	-0.014	0.004	0.012

Table 6. Growth Decomposition across Nonmetro Areas 2000 – 2010
(in Log-Point Changes)

Panel A: Growth Decomposition across the Amenity Hierarchy

	Amenity Demand			Productivity			Elasticity of Housing Supply		
	Pop	Wage	Housing	Pop	Wage	Housing	Pop	Wage	Housing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Amenity rank 2	0.030	-0.008	0.008	-0.036	-0.004	-0.013	0.003	-0.001	-0.002
Amenity rank 3	0.025	-0.006	0.006	0.004	0.000	0.002	-0.017	0.004	0.014
Amenity rank 4	0.015	-0.004	0.004	0.048	0.005	0.018	-0.011	0.003	0.009
Amenity rank 5	0.014	-0.003	0.003	0.046	0.005	0.017	0.030	-0.007	-0.025
Amenity rank 6	0.018	-0.005	0.005	0.067	0.007	0.025	0.009	-0.002	-0.008
Amenity rank 7	0.046	-0.012	0.012	0.095	0.011	0.035	-0.045	0.011	0.037
Panel B: Growth Decomposition across the Rural-Urban Continuum									
Code 4-5	-0.008	0.002	-0.002	0.048	0.005	0.018	-0.0178	0.0044	0.0148
Code 5-6	0.019	-0.005	0.005	0.007	0.001	0.002	-0.0225	0.0056	0.0188
Code 6-7	0.011	-0.003	0.003	0.009	0.001	0.003	-0.0108	0.0027	0.0090

Table 7. Growth Decomposition across Metropolitan and Nonmetropolitan Areas 2000 – 2010: Disequilibrium Sensitivity Analysis (in Log-Point Changes)

	Amenity Demand			Productivity			Elasticity of Housing Supply		
	Pop	Wage	Housing	Pop	Wage	Housing	Pop	Wage	Housing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Growth Decomposition across the Amenity Hierarchy									
Amenity rank 2	0.005	-0.001	0.001	-0.053	-0.006	-0.020	0.015	-0.004	-0.012
Amenity rank 3	-0.046	0.011	-0.011	0.062	0.007	0.023	-0.005	0.001	0.004
Amenity rank 4	-0.052	0.013	-0.013	0.109	0.012	0.040	-0.019	0.005	0.015
Amenity rank 5	-0.005	0.001	-0.001	0.092	0.010	0.034	-0.029	0.007	0.024
Amenity rank 6	-0.064	0.016	-0.016	0.186	0.021	0.069	0.009	-0.002	-0.007
Amenity rank 7	0.075	-0.019	0.019	0.184	0.020	0.068	-0.130	0.032	0.108
Panel B: Growth Decomposition across the Rural-Urban Continuum									
Code 1-2	0.078	-0.019	0.019	0.041	0.005	0.015	-0.057	0.014	0.048
Code 2-3	0.078	-0.020	0.020	0.005	0.001	0.002	-0.029	0.007	0.024
Code 3-4	0.064	-0.016	0.016	0.009	0.001	0.003	-0.042	0.011	0.035
Code 4-5	0.062	-0.015	0.015	-0.010	-0.001	-0.004	-0.042	0.010	0.035
Code 5-6	0.051	-0.013	0.013	-0.013	-0.001	-0.005	-0.053	0.013	0.044
Code 6-7	0.051	-0.013	0.013	-0.040	-0.004	-0.015	-0.046	0.012	0.039

Table 8. Growth Decomposition across Nonmetropolitan Areas 2000 – 2010: Disequilibrium Sensitivity Analysis (in Log-Point Changes)

	Amenity Demand			Productivity			Elasticity of Housing Supply		
	Pop	Wage	Housing	Pop	Wage	Housing	Pop	Wage	Housing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Growth Decomposition across the Amenity Hierarchy									
Amenity rank 2	0.021	-0.005	0.005	-0.038	-0.004	-0.014	0.003	-0.001	-0.003
Amenity rank 3	0.017	-0.004	0.004	0.009	0.001	0.003	-0.017	0.004	0.014
Amenity rank 4	-0.017	0.004	-0.004	0.063	0.007	0.023	-0.009	0.002	0.007
Amenity rank 5	-0.009	0.002	-0.002	0.100	0.011	0.037	0.029	-0.007	-0.024
Amenity rank 6	0.008	-0.002	0.002	0.145	0.016	0.054	0.007	-0.002	-0.006
Amenity rank 7	0.149	-0.037	0.037	0.124	0.014	0.046	-0.055	0.014	0.046
Panel B: Growth Decomposition across the Rural-Urban Continuum									
Code 4-5	0.094	-0.024	0.024	0.013	0.001	0.005	-0.025	0.006	0.021
Code 5-6	0.109	-0.027	0.027	-0.040	-0.004	-0.015	-0.028	0.007	0.024
Code 6-7	0.100	-0.025	0.025	-0.039	-0.004	-0.014	-0.017	0.004	0.014

Table 9. Growth Decomposition across Metropolitan and Nonmetropolitan Areas 2000 – 2010: Within Census Region Analysis (in Log-Point Changes)

	Amenity Demand			Productivity			Elasticity of Housing Supply		
	Pop	Wage	Housing	Pop	Wage	Housing	Pop	Wage	Housing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Growth Decomposition across the Amenity Hierarchy									
Amenity rank 2	0.018	-0.005	0.005	-0.072	-0.008	-0.027	0.017	-0.004	-0.014
Amenity rank 3	-0.009	0.002	-0.002	-0.017	-0.002	-0.006	0.020	-0.005	-0.016
Amenity rank 4	-0.007	0.002	-0.002	0.001	0.000	0.000	0.011	-0.003	-0.009
Amenity rank 5	0.013	-0.003	0.003	-0.021	-0.002	-0.008	0.023	-0.006	-0.019
Amenity rank 6	-0.008	0.002	-0.002	0.035	0.004	0.013	0.026	-0.006	-0.021
Amenity rank 7	0.017	-0.004	0.004	0.038	0.004	0.014	-0.023	0.006	0.019
Panel B: Growth Decomposition across the Rural-Urban Continuum									
Code 1-2	0.077	-0.019	0.019	0.028	0.003	0.010	-0.039	0.010	0.033
Code 2-3	0.041	-0.010	0.010	0.015	0.002	0.005	0.020	-0.005	-0.017
Code 3-4	0.017	-0.004	0.004	0.039	0.004	0.015	0.001	0.000	-0.001
Code 4-5	0.022	-0.006	0.006	0.010	0.001	0.004	0.004	-0.001	-0.003
Code 5-6	0.013	-0.003	0.003	0.019	0.002	0.007	-0.010	0.003	0.008
Code 6-7	0.010	-0.003	0.003	-0.005	-0.001	-0.002	-0.015	0.004	0.013

Table 10. Growth Decomposition across Nonmetropolitan Areas 2000 – 2010: Within Census Region Analysis (in Log-Point Changes)

	Amenity Demand			Productivity			Elasticity of Housing Supply		
	Pop	Wage	Housing	Pop	Wage	Housing	Pop	Wage	Housing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Growth Decomposition across the Amenity Hierarchy									
Amenity rank 2	0.031	-0.008	0.008	-0.055	-0.006	-0.020	0.022	-0.005	-0.018
Amenity rank 3	0.028	-0.007	0.007	-0.030	-0.003	-0.011	0.015	-0.004	-0.013
Amenity rank 4	0.020	-0.005	0.005	0.007	0.001	0.003	0.023	-0.006	-0.019
Amenity rank 5	0.031	-0.008	0.008	-0.012	-0.001	-0.005	0.056	-0.014	-0.046
Amenity rank 6	0.048	-0.012	0.012	-0.005	-0.001	-0.002	0.033	-0.008	-0.028
Amenity rank 7	0.100	-0.025	0.025	-0.002	0.000	-0.001	-0.031	0.008	0.026
Panel B: Growth Decomposition across the Rural-Urban Continuum									
Code 4-5	-0.007	0.002	-0.002	0.044	0.005	0.016	-0.007	0.002	0.006
Code 5-6	0.022	-0.005	0.005	0.002	0.000	0.001	-0.018	0.005	0.015
Code 6-7	0.013	-0.003	0.003	0.005	0.001	0.002	-0.009	0.002	0.008

Appendix Tables for Reviewers

Appendix Table 1. Statistic Table for Individual Characteristics across All Areas

	2000		2010	
Variables	Male	Female	Male	Female
age 31-35	0.166	0.159	0.143	0.137
	(0.372)	(0.366)	(0.350)	(0.343)
age 36-40	0.186	0.182	0.162	0.154
	(0.389)	(0.386)	(0.369)	(0.361)
age 41-45	0.180	0.183	0.174	0.172
	(0.384)	(0.387)	(0.379)	(0.377)
age 46-50	0.159	0.165	0.186	0.192
	(0.365)	(0.371)	(0.389)	(0.394)
age 51-55	0.131	0.132	0.172	0.180
	(0.338)	(0.339)	(0.378)	(0.384)
Hispanic origin	0.105	0.0882	0.127	0.110
	(0.306)	(0.284)	(0.333)	(0.313)
Black or African American	0.0795	0.114	0.0726	0.106
	(0.271)	(0.317)	(0.259)	(0.308)
Asian	0.0349	0.0353	0.0479	0.0497
	(0.184)	(0.184)	(0.214)	(0.217)
other nonwhite	0.0210	0.0214	0.0176	0.0193
	(0.143)	(0.145)	(0.131)	(0.137)
Grade 10	0.0213	0.0154	0.0156	0.0102
	(0.144)	(0.123)	(0.124)	(0.100)
Grade 11	0.0228	0.0170	0.0184	0.0123
	(0.149)	(0.129)	(0.134)	(0.110)
Grade 12	0.394	0.385	0.362	0.317
	(0.489)	(0.487)	(0.481)	(0.465)
1 yr of college	0.155	0.162	0.148	0.154
	(0.362)	(0.368)	(0.355)	(0.361)
2 yr of college	0.0732	0.0958	0.0821	0.112
	(0.261)	(0.294)	(0.274)	(0.316)
4 yr+ of college	0.288	0.297	0.335	0.371
	(0.453)	(0.457)	(0.472)	(0.483)
27-39 weeks	0.0414	0.0683	0.0434	0.0576
	(0.199)	(0.252)	(0.204)	(0.233)
40-47 weeks	0.0625	0.0925	0.0559	0.0766
	(0.242)	(0.290)	(0.230)	(0.266)
48-49 weeks	0.0487	0.0492	0.0348	0.0357
	(0.215)	(0.216)	(0.183)	(0.186)
50+ weeks	0.816	0.738	0.837	0.795

	(0.388)	(0.440)	(0.369)	(0.404)
30-34 hrs	0.0214	0.0737	0.0316	0.0807
	(0.145)	(0.261)	(0.175)	(0.272)
35-39 hrs	0.0296	0.0910	0.0390	0.103
	(0.169)	(0.288)	(0.194)	(0.304)
40 hrs	0.479	0.530	0.479	0.504
	(0.500)	(0.499)	(0.500)	(0.500)
41-48 hrs	0.138	0.0935	0.132	0.0934
	(0.345)	(0.291)	(0.339)	(0.291)
49-59 hrs	0.188	0.0860	0.179	0.0888
	(0.391)	(0.280)	(0.383)	(0.284)
60+ hrs	0.0508	0.0172	0.0475	0.0164
	(0.220)	(0.130)	(0.213)	(0.127)
have child	0.537	0.575	0.533	0.563
	(0.499)	(0.494)	(0.499)	(0.496)
have child 5-yrs	0.182	0.143	0.176	0.138
	(0.386)	(0.351)	(0.380)	(0.345)
English at home	0.834	0.853	0.811	0.830
	(0.372)	(0.354)	(0.391)	(0.376)
English poor	0.0343	0.0260	0.0399	0.0303
	(0.182)	(0.159)	(0.196)	(0.171)
married	0.705	0.656	0.700	0.650
	(0.456)	(0.475)	(0.458)	(0.477)
veteran	0.180	0.0174	0.108	0.0168
	(0.385)	(0.131)	(0.310)	(0.129)
immigration	0.143	0.120	0.170	0.148
	(0.350)	(0.325)	(0.376)	(0.355)
managerial and professional specialty occupations	0.271	0.344	0.306	0.395
	(0.445)	(0.475)	(0.461)	(0.489)
technical, sales, and administrative support occupations	0.201	0.394	0.208	0.367
	(0.401)	(0.489)	(0.406)	(0.482)
service occupations	0.0866	0.150	0.0930	0.155
	(0.281)	(0.357)	(0.291)	(0.362)
farming, forestry, and fishing occupations	0.0310	0.00722	0.0305	0.00718
	(0.173)	(0.0847)	(0.172)	(0.0844)
precision production, craft, and repair occupations	0.207	0.0251	0.181	0.0212
	(0.405)	(0.157)	(0.385)	(0.144)
operators, fabricators, and laborers	0.196	0.0788	0.172	0.0523
	(0.397)	(0.269)	(0.378)	(0.223)
agriculture, forestry, and fisheries	0.0286	0.00940	0.0294	0.0108
	(0.167)	(0.0965)	(0.169)	(0.103)
mining	0.00837	0.00137	0.00948	0.00167
	(0.0911)	(0.0370)	(0.0969)	(0.0408)

construction	0.126	0.0160	0.131	0.0162
	(0.332)	(0.126)	(0.337)	(0.126)
manufacturing	0.212	0.122	0.175	0.0870
	(0.409)	(0.328)	(0.380)	(0.282)
transportation, communications, and other public utilities	0.104	0.0521	0.101	0.0459
	(0.306)	(0.222)	(0.302)	(0.209)
wholesale trade	0.0489	0.0252	0.0431	0.0220
	(0.216)	(0.157)	(0.203)	(0.147)
retail trade	0.120	0.144	0.121	0.136
	(0.325)	(0.351)	(0.326)	(0.343)
finance, insurance, and real estate	0.0483	0.0876	0.0581	0.0906
	(0.214)	(0.283)	(0.234)	(0.287)
business and repair services	0.0703	0.0467	0.0746	0.0471
	(0.256)	(0.211)	(0.263)	(0.212)
personal services	0.0159	0.0396	0.0158	0.0394
	(0.125)	(0.195)	(0.125)	(0.195)
entertainment and recreation services	0.0127	0.0116	0.0123	0.0113
	(0.112)	(0.107)	(0.110)	(0.106)
professional and related services	0.142	0.390	0.163	0.437
	(0.349)	(0.488)	(0.369)	(0.496)
public administration	0.0547	0.0524	0.0568	0.0530
	(0.227)	(0.223)	(0.231)	(0.224)
Observations	2,484,076	2,111,043	2,446,711	2,156,904

Standard Deviation in parentheses *** p<0.01, ** p<0.05, * p<0.1

Appendix Table 2. Statistics Table for Housing Characteristics

	2000		2010	
Variables	Owners	Renters	Owners	Renters
located on 10+ acres	0.0562	0.0174	0.132	0.0503
	(0.230)	(0.131)	(0.338)	(0.218)
used commercially	0.0390	0.0139	0.0295	0.0118
	(0.194)	(0.117)	(0.169)	(0.108)
2-4 rooms	0.111	0.520	0.0937	0.367
	(0.314)	(0.500)	(0.291)	(0.482)
5-8 rooms	0.745	0.425	0.750	0.586
	(0.436)	(0.494)	(0.433)	(0.493)
9+ rooms	0.142	0.0170	0.155	0.0385
	(0.349)	(0.129)	(0.362)	(0.192)
complete plumbing facilities	0.996	0.993	0.996	0.995
	(0.0598)	(0.0852)	(0.0645)	(0.0724)
access to kitchen	0.997	0.992	0.996	0.992
	(0.0516)	(0.0881)	(0.0653)	(0.0872)
Age category 1	0.104	0.0505	0.0921	0.0569
	(0.306)	(0.219)	(0.289)	(0.232)
Age category 2	0.0962	0.0562	0.187	0.131
	(0.295)	(0.230)	(0.390)	(0.337)
Age category 3	0.168	0.154	0.284	0.316
	(0.374)	(0.361)	(0.451)	(0.465)
Age category 4	0.173	0.201	0.213	0.288
	(0.379)	(0.401)	(0.410)	(0.453)
Age category 5	0.109	0.151	0.179	0.178
	(0.312)	(0.358)	(0.384)	(0.382)
Age category 6	0.115	0.126		
	(0.319)	(0.332)		
Age category 7	0.0603	0.0838		
	(0.238)	(0.277)		
bedroom/room	0.661	0.736	0.662	0.715
	(0.125)	(0.156)	(0.132)	(0.140)
Observations	3,380,974	1,214,145	653,100	133,898

For the 2000 sample the age categories are in table order: 2-5 years, 6-10 years, 11-20 years, 21-30 years, 31-40 years, 41-50 years and over 50 years. For the 2010 sample the age categories are in table order: 2000-2004, 1990-1999, 1970-1989, 1940-1969 and earlier than 1940.

Standard Deviations are in parentheses *** p<0.01, ** p<0.05, * p<0.1