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Jordan Rappaport

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Jordan Rappaport*
Federal Reserve Bank of Kansas City

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Abstract

The U.S. population has been migrating to places with high perceived quality of life. With homothetic preferences, such migration can follow from the increased demand for amenities that accompanies broad-based technological progress. Under the baseline calibration of a general equilibrium model, a place with amenities for which individuals would initially pay five percent of their income grows slightly faster than an otherwise identical place. As quality of life becomes more important in determining relative population density, productivity independently becomes less important. Asymptotically, local amenities are the sole determinant of relative density. High quality of life together with low relative productivity can boost metropolitan population growth by several percentage points.

JEL Classification: O40, R12, R13

Keywords: Migration, Consumption Amenities, Quality of Life, Productivity, Urban Agglomeration

*Economic Research Department, 1 Memorial Drive Kansas City, Missouri 64198. Telephone: (816) 881-2018. Fax: (816) 881-2199. Email: jordan.rappaport@kc.frb.org. A previous version of this paper was circulated under the title "Moving to High Quality of Life". Thank you for advice and feedback to Gilles Duranton, Steven Durlauf, Vernon Henderson, Ping Wang, two anonymous referees, and seminar participants at Washington University and the 2007 North American Regional Science Association International meetings. Scott Benolkin, Martina Chura, Taisuke Nakata, and Aarti Singh provided excellent research assistance. The views expressed herein are those of the author and do not necessarily reflect the position of the Federal Reserve Bank of Kansas City or the Federal Reserve System.

1 Introduction

U.S. residents have been moving to places with high perceived quality of life. One example is the faster population growth of places with nice weather. Throughout much of the twentieth century, U.S. county population growth was strongly positively correlated with warm winter temperatures and cool summer ones (Rappaport, 2007). San Diego's ideal climate, for example, was associated with population growth that was above the U.S. 1970-to-2000 average by 1.1 percent per year. For metro areas, winter weather alone accounted for 44 percent of the variation in growth from 1950 to 2000 (Figure 1). A second example of movement to high perceived quality of life is the faster growth of coastal locations. After controlling for shoreline and proximity to natural harbors, counties with centers within 80 kilometers of an ocean coast had faster expected annual population growth of 0.4 percent from 1960 to 2000 (Rappaport and Sachs, 2003). A third example of movement to high perceived quality of life is the recent resurgence of population in cities with high levels of consumption amenities such as restaurants and live performance venues (Glaeser, Kolko, and Saiz, 2001).

Partly as a result of these trends, numerous specific metro areas grew rapidly over the post-war era. Between 1950 and 2000, Miami, Orlando, and Phoenix each grew by an annual average of more than 4 percent. Tampa, San Diego, and Austin each grew by well above 3 percent. For comparison, mean annual growth among medium and large metro areas over the same period was 1.4 percent.

A simple general-equilibrium model characterized by broad-based technological progress can account for much of the faster growth of high-amenity metro areas. The model, the same as in Rappaport (2008), assumes that homogeneous individuals derive utility from consumption of a traded good, housing, leisure, and local consumption amenities. Firms produce the traded good and housing using land, capital, and labor. Perfect labor mobility assures that utility is equated across localities.

In such a setting, a metro area with above-average consumption amenities—or, equivalently, above-average quality of life—will have above-average population density as well. The higher density is required to support higher house prices, which in turn equate utility across metro areas. Rappaport (2008) finds that under the same baseline calibration that is used below, the observed 20-fold population density difference between the second-most-dense and least-dense U.S. metropolitan areas can be supported by a difference in consumption amenities valued at 30 percent of average consumption. Amenity differences of this magnitude are consistent with empirical estimates.

The present paper takes the higher density associated with higher amenities as its starting point. Rather than focusing on this initial static equilibrium, it studies the pseudo dynamics that follow from a series of static outcomes over time that differ from each other due to total factor productivity that is gradually rising in all metro areas. Complementarity between goods consumption and amenities consumption causes migration towards high-amenity locations in order to support the increase in relative house prices required to maintain a spatial equilibrium. Notwithstanding homothetic utility, individuals implicitly choose to spend an increasing share of their rising wealth on quality of life. The movement towards high quality of life is in no way built into the model. Under alternative parameterizations, migration is away from high quality of life. A thorough sensitivity analysis shows when this is the case.

The increasing importance of quality of life is relatively weak on its own. Under the baseline parameterization, a metro area with high amenities experiences only modest population growth. But independent of the elevation of quality of life, shared productivity growth also causes productivity differences among places to become less important. Asymptotically, local amenities are the sole determinant of relative density. High quality of life together with low relative productivity can boost metropolitan population growth to the high rates experienced by booming post-War U.S. metro areas. Conversely, high relative productivity reverses the faster growth associated with high quality of life.

The methodology herein combines some of the quantitative elements of the dynamic stochastic general equilibrium (DSGE) literature inaugurated by Kydland and Prescott (1982) with the qualitative elements that characterize more theoretical work. A structural model, including specific functional forms, is assumed. The model abstracts from numerous characteristics of potential first-order importance. Functional forms are parameterized using a combination of microeconomic estimation results, national aggregate first moments, and correlations among metro-area aggregate variables. The parameterization includes the choice of baseline values as well as a wide range around these with which to conduct a sensitivity analysis, which helps to illuminate how the model works. The parameterized model is then compared to the long-run growth of some hypothesized high-amenity metro areas to see whether it can approximately replicate observed outcomes.

The model's results complement Gyourko, Mayer, and Sinai (2006). They emphasize the faster house-price appreciation and increasingly right-skewed income distribution of metro areas where housing supply is constrained. The resulting "superstar" cities need not have any inherent advantage in consumption amenities or productivity. Nevertheless, the actual superstar metros discussed in Gyourko, Meyer, and Sinai appear to be disproportionately made up of places with high amenities such as San Francisco, Los Angeles, Boston, and New York. In contrast to Gyourko, Mayer and Sinai, the present model assumes homogeneous labor endowments. But the result that people move to high-quality-of-life places as they become wealthier over time strongly suggests that those who are wealthier first will move first.

The model's predictions are supported empirically by Costa and Kahn (2003), who find that the implicit price of locational amenities has risen rapidly over time. But, as will be shown below, a rising price of amenities need not coincide with any migration towards them. The predictions are also consistent with Shapiro (2006), who finds that approximately one third of the faster employment growth associated with a high share of college graduates actually arises from the increases in consumption amenities demanded by high-human-capital residents.

The paper proceeds as follows. Section 2 lays out a general-equilibrium model in which individuals must be indifferent between living in either of two locations. Section 3 discusses the model's parameterization. Important choices include factor income shares, elasticities of substitution in production, and elasticities of substitution in consumption. Section 4 shows the evolution of relative population density and relative prices for the location with higher quality of life when total factor productivity is increasing in both places.

2 Model

The model uses a static, open-city framework. The world is made up of a city economy and a national economy. The city economy corresponds to a single metropolitan area in which individuals both live and work. The national economy can be interpreted as the aggregate of numerous city economies. It establishes the reservation level of utility that the city economy must offer individuals, who are mobile. In the parlance of international trade theory, the national economy is "large" and the city economy is "small". That is, outcomes in the national economy affect outcomes in the city economy but *not* vice versa.[1] This framework is identical to that in Rappaport (2008a) and similar to those in Henderson (1974, 1987, 1988), Haurin (1980), Upton (1981), and Haughwout and Inman (2001). The equilibrium equating of utility and capital returns across localities embeds the compensation for quality-of-life differences that forms the basis of empirical work in Rosen (1979), Roback (1982), Blomquist et al. (1988), Gyourko and Tracy (1989, 1991), Gabriel and Rosenthal (2004), Chen and Rosenthal (2006), and Albuoy (2008).

2.1 Firms

Within each economy ($i = c, n$), perfectly competitive firms employ a constant-returns-to-scale production function that combines land, capital, and labor (D_i, K_i, and L_i) to produce a traded numeraire good and nontraded housing (X_i and H_i). Housing must be consumed in the economy in which it is produced. Aggregate production within each economy is given by

$$X_i = \mathrm{A}_{X,i}\, D_{X,i}^{\alpha_{X,D}}\, K_{X,i}^{\alpha_{X,K}}\, L_{X,i}^{\alpha_{X,L}} \tag{1}$$

$$H_i = \mathrm{A}_{H,i} \left(\eta_{D,KL} D_{H,i}^{\frac{\sigma_{D,KL}-1}{\sigma_{D,KL}}} + \left(1-\eta_{D,KL}\right) \left(K_{H,i}^{\alpha_{H,K}} L_{H,i}^{\alpha_{H,L}} \right)^{\frac{\sigma_{D,KL}-1}{\sigma_{D,KL}}} \right)^{\frac{\sigma_{D,KL}}{\sigma_{D,KL}-1}} \tag{2}$$

Production of the traded good is Cobb-Douglas. The factor income share parameters are each assumed to be strictly positive, with $\alpha_{X,D} + \alpha_{X,K} + \alpha_{X,L} = 1$. Production of housing has a constant elasticity of substitution with respect to land and an implicit intermediate product of capital and labor. The elasticity of substitution between land and the capital-labor intermediate good is given by $\sigma_{D,KL}$. The weighting parameter $\eta_{D,KL}$, which lies strictly between 0 and 1, calibrates the relative share of factor income accruing to land. The capital-labor intermediate hybrid good is produced with constant returns to scale: $\alpha_{H,K} + \alpha_{H,L} = 1$. These coefficients determine the division of factor income between capital and labor.

[1] Modelling a national economy establishes a benchmark against which the modeled city economy outcomes can be measured. Doing so also allows for the comparison among several city economies with differing initial conditions. Results from modelling two interdependent economies should be qualitatively similar.

Total factor productivities, $\mathrm{A}_{X,i}$ and $\mathrm{A}_{H,i}$, are each assumed to include components common to both economies that increase at rates γ_X and γ_H along with components that differ between economies, possibly as endogenous functions of local population density, N_i/D_i.

$$\mathrm{A}_{X,i} = \widetilde{\mathrm{A}}_{X,i}\big(N_i/D_i\big)\, \mathrm{e}^{\gamma_X t} \tag{3a}$$

$$\mathrm{A}_{H,i} = \widetilde{\mathrm{A}}_{H,i}\big(N_i/D_i\big)\, \mathrm{e}^{\gamma_H t} \tag{3b}$$

Under the baseline calibration below, total factor productivity components $\widetilde{\mathrm{A}}_{X,i}$ and $\widetilde{\mathrm{A}}_{H,i}$ are each assumed to be identical between economies and hence not to depend on density.

Profit maximization by perfectly competitive firms induces demand such that each of the factors is paid its marginal revenue product. Frictionless intersectoral mobility assures intersectoral factor price equalization within each economy. Capital is additionally assumed to be perfectly mobile across economies. Hence its return must be the same in both economies. Because the present framework is static, this identical capital rent is taken as exogenous. In a dynamic neoclassical framework, it would equal the real interest rate plus the rate of capital depreciation.

2.2 Individuals

Individuals derive utility from consumption of the traded good, housing, leisure, and consumption amenities. The level of consumption amenities—or, equivalently, quality of life—is assumed to vary exogenously between the two economies. It thereby serves as the model's primary source of crowding.

Utility is assumed to take a nested constant-elasticity-of-substitution functional form. Let $\sigma_{a,b}(\cdot)$ be a CES aggregator over a and b:

$$\sigma_{a,b}(a_i, b_i) \equiv \left(\eta_{a,b}\, a_i^{\frac{\sigma_{a,b}-1}{\sigma_{a,b}}} + \big(1-\eta_{a,b}\big)\, b_i^{\frac{\sigma_{a,b}-1}{\sigma_{a,b}}} \right)^{\frac{\sigma_{a,b}}{\sigma_{a,b}-1}}$$

Utility in each economy is given by

$$U_i = \sigma_{xhl,q}\big(\, \sigma_{xh,l}\big(\, \sigma_{x,h}(x_i, h_i)\, ,\, leisure_i\big)\, ,\, quality_i\big) \tag{4a}$$

The innermost nesting in (4a) is between the traded good and housing. It has elasticity $\sigma_{x,h}$. The middle nesting is between the resulting traded-good-housing composite and leisure.

It has elasticity $\sigma_{xh,l}$. The outermost nesting, between the traded-good-housing-leisure composite and quality of life, has elasticity $\sigma_{xhl,q}$. For each of the three nestings, the calibration determines the associated weighting parameter, η.

In the special case when the elasticity of substitution is equal across nestings, (4a) simplifies to a standard CES functional form,

$$U_i = \left(\eta_x x_i^{\frac{\sigma-1}{\sigma}} + \eta_h h_i^{\frac{\sigma-1}{\sigma}} + \eta_l leisure_i^{\frac{\sigma-1}{\sigma}} + \eta_q quality_i^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{4b}$$

This specialization indeed characterizes the baseline calibration below. With a unitary elasticity of substitution, $\sigma = 1$, (4b) further reduces to Cobb-Douglas utility.

Optimizing behavior by individuals equates the ratio of marginal utility to price *within* each economy. Individuals must each satisfy a budget constraint that their expenditure equal the sum of their wage and non-wage income. Non-wage income is the per-capita sum of all capital and land rents collected in the two economies. Non-wage income thus does not depend on where one lives. Finally, and most critically, individuals' mobility equates utility levels between the city and national economies:

$$U_c = U_n \tag{5}$$

As quality of life has no natural units, it will instead be measured by individuals' willingness to pay to receive $quality_c$ rather than $quality_n$. Let p_i be the price of housing in terms of the numeraire consumption good. Consider the minimum expenditure function required to obtain the national-economy level of utility at the national-economy wage-price vector, $\{w_n, p_n\}$. For present purposes, this expenditure is defined to include the opportunity cost of leisure.

$$\mathrm{e}(w_n, p_n, quality; U_n) \equiv \mathrm{Min}\,(x + p_n\, h + w_n\, leisure) \text{ s.t. } \mathrm{u}(x, h, leisure, quality) = U_n.$$

The compensating variation, CV, of $quality_c$ measures an individual's willingness to pay to receive it rather than $quality_n$. It is defined as the negative transfer required for a person facing $\{w_n, p_n, quality_c\}$ to achieve U_n. That is,

$$CV \equiv \mathrm{e}(w_n, p_n, quality_n; U_n) - \mathrm{e}(w_n, p_n, quality_c; U_n)$$

Note that CV is defined to be positive when $quality_c$ exceeds $quality_n$. To facilitate intuition on magnitudes, a normalized measure, $\widetilde{CV}$, divides CV by actual national-economy expenditure, $x_n + p_n\, h_n$.[2]

2.3 Closure

In addition to the profit and utility maximization conditions, several adding-up constraints must be met. For each of the economies, the land and labor factor markets and the housing market must clear. The sum across the two economies of traded-good consumption must equal the sum across the two economies of traded-good production. And the sum of local populations must equal the exogenously-given total population.

The combined optimization conditions, individual budget constraints, local adding-up constraints, and global adding-up constraint can be reduced to two nonlinear systems of seven equations each. The first system is used to solve outcomes for the national economy including the calibration of the weighting parameters. The second system is then used to solve outcomes for the city economy. In the absence of any sort of increasing returns to scale, the fixed land supply and decreasing marginal utility together suggest that the solution to this combined system is unique. However, there may be multiple equilibria when either of the TFP components, $\widetilde{\mathrm{A}}_{X,i}(\,\cdot\,)$ or $\widetilde{\mathrm{A}}_{H,i}(\,\cdot\,)$, is allowed to be increasing with respect to density.

3 Parameterization

The primary purpose of the present paper is to see whether a relatively simple model of locational choice and shared technological progress can approximate the observed strong migration towards high-amenity places. A complementary purpose is to better understand the mechanisms within the model by which such migration arises. In this spirit, and to not imply a false level of precision, parameters are set to round values. A more detailed discussion of the calibration is included in Rappaport (2008a).

3.1 Production

The calibration of production requires determining the national-economy factor income share accruing to each of land, capital, and labor in the traded-good and housing sectors. For the

[2] CV can differ significantly from the compensating differential, CD, of $quality_c$ relative to $quality_n$ (Rappaport, 2008a). CD equals $(p_c - p_n)\, h_n - (w_c - w_n)\,(1 - leisure_n)$ (Rosen, 1979; Roback, 1982).

housing sector, it also requires determining the elasticity of substitution between land and the capital-labor composite. In addition, the rate of return determining capital intensity needs to be specified. Table 1 summarizes the baseline parameterization and alternative values for the sensitivity analysis.

The land share of factor income derived from the production of the traded good is assumed to be 1.6%. This value is a weighted average across a large number of industries using intermediate input shares estimated by Jorgenson, Ho, and Stiroh (2005). It is nearly identical to the 1.5% land share that Ciccone (2002) suggests is reasonable for the manufacturing sector. Sensitivity analysis is conducted for land factor shares equal to 0.4% and 4.8%. One third of remaining factor income is assumed to accrue to capital; two thirds are assumed to accrue to labor (Gollin, 2002). Because traded-good production is Cobb Douglas, the assumed factor shares hold in both economies.

Non-Cobb-Douglas production in the housing sector implies that its factor income shares differ between the two economies. Under the baseline parameterization, land's national-economy value is set to 35%. This is slightly below a recent estimate by Davis and Heathcote (2005) but well above estimates by Jackson, Johnson, and Kaserman (1984) and Thorsnes (1997). For the sensitivity analysis, the housing land-factor share is assumed to equal 20% and 50%. As with traded-good production, one third of remaining factor income is assumed to accrue to capital; two thirds is assumed to accrue to labor.

The elasticity of substitution between land and non-land inputs, $\sigma_{D,KL}$, is assumed to be 0.75. No clear consensus exists on an appropriate value. A survey by McDonald (1981) reports preferred estimates from twelve different studies ranging from 0.36 to 1.13. Updating this research, Jackson, Johnson, and Kaserman (1984) estimate the elasticity to lie somewhere between 0.5 and 1. More recently, Thorsnes (1997) argues that a unitary elasticity of substitution cannot be rejected. For the sensitivity analysis, $\sigma_{D,KL}$ is assumed to equal 0.5 and 1.

Finally, the rent on the services of capital goods, r_K, is set to 0.08, which implicitly represents the sum of a required annual real return plus an annual allowance for depreciation. However, the main results are completely insensitive to this choice, which makes sense, since the static framework has no natural time context.

The numerical exercise assumes that *traded-good* TFP in both economies increases at an annual rate of 1%. This is slightly above a recent estimate of average U.S. TFP growth from

1959 to 1998 (Jorgenson and Stiroh, 2000). But more relevant for present purposes is that the assumed 1% TFP growth implies labor productivity growth of approximately 1.5%, well below what is estimated by the same authors. The implied labor productivity growth is also consistent with numerous corresponding estimates for various periods from the mid-1970s through 2000 (e.g., Oliner and Sichel, 2000, 2002; Jorgenson, Ho, and Stiroh, 2002; Basu, Fernald, Oulton, and Srinivasan, 2003).

TFP in the production of housing is assumed to remain constant. Technological progress has clearly increased productivity faster in the traded-good than in the housing sector: the process of building a car has evolved considerably more over the past 50 years than the process of building a house. Moreover, technological progress has introduced numerous new goods and services into the traded-good consumption bundle. Estimates suggest that trend productivity growth in the residential construction may be as low as zero and as high as two-fifths of TFP growth for traded goods (Gort, Greenwood, and Rupert, 1999; Corrado et al., 2007; Iacoviello and Neri, 2008). As discussed in the sensitivity discussions below, allowing for TFP growth in the construction of housing speeds migration towards places with high quality of life but slows it towards places with low productivity.

3.2 Utility

The calibration of the utility function, (4a), requires parameterizing the elasticities of substitution between the traded good and housing, between the resulting two-way composite and leisure, and between the resulting three-way composite and quality of life. In addition, weighting parameters that determine the national-economy share of consumption spent on housing and the national-economy share of time devoted to leisure need to be set.

The elasticity of substitution, $\sigma_{x,h}$, is assumed to equal 0.5. It is calibrated using cross-sectional data on housing prices and the housing share of consumption expenditures for 24 large metro areas, as described in Rappaport (2008a). This baseline value implies a price elasticity of housing demand that is close to numerous estimates (Goodman, 1988, 2002; Ermisch, Findlay, and Gibb, 1996; Ionnides and Zabel, 2003). For the sensitivity analysis, $\sigma_{x,h}$ is assumed to equal 0.25 and 0.75.

The elasticity of substitution between the traded-good-housing composite and leisure, $\sigma_{xh,leisure}$, is also assumed to equal 0.5. It is calibrated using time diary studies taken in

1965, 1975, 1985, 1993, and 2003 (Robinson and Godbey, 1997; Aguiar and Hurst 2006) and real wage data for each of these years, also as described in Rappaport (2008a). The implied negative elasticity of labor hours with respect to the permanent real wage is consistent with numerous estimates summarized in Pencavel (1986) but potentially contrasts with more recent research described in Blundell and MaCurdy (1999). However, it is difficult to map the life-cycle context of observed individual labor choice into the present static context. As shown below, migration is relatively insensitive to setting $\sigma_{xh,leisure}$ equal to 0.25 and to 1.

The elasticity parameter between the traded-good-housing-leisure composite and quality of life, $\sigma_{xhl,quality}$, is also set to 0.5. Setting $\sigma_{xhl,quality}$ equal to the common value of $\sigma_{x,h}$ and $\sigma_{xh,l}$ seems the most natural choice, given the absence of any microeconomic data with which to calibrate it. Doing so has the additional benefit of simplifying (4a) to its standard CES form, (4b). The magnitude of the migration to high-quality-of-life localities depends closely on $\sigma_{xhl,quality}$. This will be shown in a sensitivity analysis that alternatively sets $\sigma_{xhl,quality}$ to 0.25 and to 1.

Finally, the weighting parameters $\eta_{x,h}$ and $\eta_{xh,leisure}$ need to be calibrated. For a given set of elasticities, $\eta_{x,h}$ is chosen such that national-economy individuals spend 11% of their consumption expenditures on housing. This matches the estimated share of consumption expenditure devoted to non-farm owned and rented housing in 1950, as reported in Lebergott (1993). The sensitivity analysis alternatively assumes national-economy housing expenditure shares of 6% and 16%. The parameter $\eta_{xh,leisure}$ is chosen such that national-economy individuals choose to spend 28% of their time on leisure.[3] This value is an extrapolation backward to 1950, based on time studies taken in 1965, 1975, 1985, 1993, and 2003 (Robinson and Godbey, 1997; Aguiar and Hurst 2006). The sensitivity analysis alternatively assumes national-economy leisure shares of 14% and 42%. As will become clear, all numerical results are extremely robust to these latter variations.[4]

[3]Biological necessities are assumed to require 9 hours per day, which leaves 105 hours per week of potential leisure.

[4]The lack of units for *quality* makes the choice of $\eta_{xhl,quality}$ immaterial.

4 Numerical Results

Both the national and city economies are assumed to have *constant* levels of consumption amenities with $quality_c > quality_n$. Because of its higher level of amenities, the city economy will tend to have a higher population density than does the national economy. But the difference in population density between the two additionally depends on their relative productivity levels.

The model's mechanics are straightforward. National-economy quality of life, $quality_n$, can be set arbitrarily. Then, for an initial year, the national economy serves to calibrate the utility and production weighting parameters so as to hit certain targets. The resulting national-economy level of utility must be matched in the city economy. City-economy quality of life, $quality_c$, is then determined to achieve a target normalized compensating variation, $\widetilde{CV}$, in the initial year. Given national-economy utility and city-economy quality of life, the city-economy equilibrium can then be solved. Finally, for subsequent years with their associated higher levels of productivity in both economies, equilibrium outcomes are solved first for the national economy and then for the city economy. The absolute levels of amenities, $quality_n$ and $quality_c$, remain constant over time. But the relative valuation of these amenities varies.

4.1 Baseline Calibration: National Economy

The focus of this paper is the change in outcomes of the city economy relative to the national economy as productivity increases in both places. To understand such a relative outcome, it is helpful to briefly describe the absolute outcome in the national economy alone.

Figure 2 shows the evolution of several national-economy equilibrium outcomes over fifty years, which are meant to correspond to 1950 through 2000. By assumption, traded-good total factor productivity grows at a 1 percent annual rate. In addition to increasing wages directly, the productivity growth causes some capital deepening, with the result that traded-good-denominated wages grow moderately faster than does TFP (Panel A).

By assumption, traded-good productivity growth is not matched by housing productivity growth. The national economy's production possibility frontier shifts such that each additional unit of housing requires a larger sacrifice of traded goods. Hence the price of housing in terms of the traded good must rise (Panel B). This is an example of the Harrod-Balasa-

Samuelson effect (Harrod, 1933; Balassa, 1964; Samuelson, 1964). For the reasons underpinning the Stolper-Samuelson Theorem, the rise in housing prices causes land price growth to exceed wage growth (Panel A). Land prices grow directly due to productivity growth, indirectly due to the accumulation of complementary capital, and for general-equilibrium reasons due to the rise in price of the good for which land is a relatively intensive factor.

Notwithstanding their rising prices, individuals use some of their increased wealth to consume more housing and leisure (Panel C). This increased consumption follows directly from the assumed complementarity in consumption among the traded good, housing, and leisure ($\sigma_{x,h}$ and $\sigma_{xh,l}$ are each less than one). Correspondingly, housing expenditure increases at a faster rate than does the price of housing (Panel B). And housing's share of explicit consumption expenditure rises with time (Panel D).

The modeled growth rates are a relatively good match to observed aggregate dynamics. Under the baseline calibration, real wages grow at 1.3% per year. This approximately matches U.S. average real wage growth from 1950 to 2000 of 1.5% per year. Modeled real housing expenditure grows at 1.7% per year. This approximately matches average metro-area real housing expenditure growth from 1950 to 2000 of 1.6%. In addition, national-economy leisure increases from its assumed 0.28 share in 1950 to 0.34 in 2000. This almost matches the actual 0.35 share based on the time-diary studies.[5]

4.2 Baseline Calibration: City Economy

The city economy is assumed to have higher quality of life than does the national economy such that national-economy residents would be willing to pay 5 percent of their income in 1950 to receive $quality_c$ rather than $quality_n$ while continuing to face national economy wages and prices.[6] The two economies have identical productivity. As individuals in both economies become richer over time, they increasingly value the city economy's higher amenities. The

[5] Real wage growth is based on the BLS's nonfarm business hourly compensation index divided by CPI. Real housing expenditure growth is calculated as a population-weighted mean of growth rates for the 132 metro areas with a population of at least 150,000 in 1950. Metro area housing expenditures in 1950 and 2000 are calculated as a population-weighted mean of constituent counties' median house values divided by national CPI. Metro-area boundaries are based on the 2003 OMB definitions.

[6] This initial $\widetilde{CV}$ approximates Costa and Kahn's (2003) estimate of the extra rent one would have to pay in 1970 to receive San Francisco's weather instead of Chicago's weather.

valuation of the constant amenity difference increases to 9% of income in 2000 (Figure 3 Panel A). This represents a more than three-fold increase in the absolute compensating variation, another example of the Harrod-Balasa-Samuelson effect.

The rise in valuation of the city economy's quality of life is accompanied by slow immigration (Panel B). As people become increasingly willing to trade off the city economy's high housing prices and low wages in return for its high amenities, the city economy's relative density increases from 1.96 in 1950 to 2.30 in 2000.

This migration to high quality of life is by no means built into the system. Preferences are homothetic and hence quality of life is *not* a luxury good. Under alternative parameter and relative productivity assumptions discussed below, migration can be away from high quality of life. In that case, the city-economy wage-price vector that would prevail were population to remain unchanged implies an excessive valuation of the city economy's amenities. Under the base calibration, however, only an increase in the city-economy population can support the wage-price vector that equalizes utility between the two economies

Increased demand to live in the city economy puts strong upward pressure on relative land prices (not shown) and moderate upward pressure on relative house prices (Figure 3 Panel C, upper line). But relative *expenditure* on housing rises only slightly, due to falling relative consumption of housing (Panel C, lower line). Because of the city economy's high amenities, land prices, house prices, and housing expenditures all begin in 1950 at significantly higher levels than in the national economy. Notwithstanding the population inflow, relative wages remain relatively unchanged at just slightly below the national economy level (Panel D). This reflects that amenities are primarily capitalized into housing prices.[7]

As a source of quantitative comparison with the simulated results, the top of Table 2 shows population and housing expenditure growth rates for nine metro areas that are hypothesized to have high consumption amenities. Five of the metro areas were chosen for being the top-ranked quality of life cities in Gabriel and Stuart (2004). The remaining four were chosen for being ranked among the top 20 in both Savageau (2000) and Sperling (2004) (as recalculated by Rappaport, 2008a). Of course, it may be that these rankings are poorly measured and that some of these metros do not have high amenities. All that is important for present purposes is that at least some of them do. Compared with aggregate population

[7]The much higher capitalization of amenities into housing prices rather than into wages is a robust characteristic of the present model (Rappaport, 2008a).

growth for 132 medium and large metro areas from 1950 to 2000, population growth for the nine hypothesized high-amenity metro areas ranged from 2.6 percent faster for Miami down to 0.7 percent slower for New York. Housing expenditure annual growth ranged from 1.3 percent faster for San Francisco to 0.3 percent slower in Miami and Tampa.

Relative population growth under the baseline calibration is in the middle of the observed range (Table 2). It is considerably below the relative population growth rates of Miami, Tampa, San Diego, and Denver but considerably above the negative relative population growth rates of Boston and New York. As shown in Section 4.5 below, the model can match this observed range by allowing for different relative productivity levels.

Under the baseline, the valuation of the constant quality-of-life difference, $quality_c$ versus $quality_n$, rises at a 2.2 percent annual rate. An empirical source of comparison finds much faster appreciation. Costa and Kahn (2003) estimate that the implicit price of obtaining San Francisco's weather over that of Chicago rose at a 9.2 percent annual rate between 1970 and 1990.

The appreciation of CV gets capitalized mostly into the city-economy relative housing price, p_c/p_n. It rises at a 0.3 percent annual rate. No good measure of house prices is available over the entire period, 1950 to 2000, but this differential rate of house price growth in the model may be a bit low. Based on one of the best measures of U.S. home prices, the OFHEO index, differential price growth for the nine metro areas from 1978 to 2000 ranged from approximately zero percent for Miami and Tampa up to approximately 3.2 percent for Boston and San Francisco (not shown).

Modeled relative housing expenditure growth is also on the low end of observed rates. Per capita housing consumption rises slower in the city economy than in the national one. City-economy relative housing expenditure must therefore rise slower than the rate of relative price appreciation. The modeled 0.1-percent-per-year rate at which it does so compares with actual relative expenditure growth of 0.4 percent or higher for six of the nine hypothesized high-quality-of-life metro areas.

Overall, the baseline calibration of the model predicts time paths that are consistent with the growth of the hypothesized high-amenity economies. But it can do so primarily because the observed time paths are so diffuse.

4.3 Alternative Parameterizations

Parameterizing the model requires potentially controversial choices. But the migration towards high quality of life proves fairly robust. Among large variations to the baseline value of each of the model's eight key parameters, only a high elasticity of substitution with quality of life reverses the result. Conversely, only a low elasticity of substitution with quality of life comes close to matching high observed relative population growth rates. An additional benefit of the sensitivity analysis is that it builds intuition on the model's mechanics.

For building intuition, a Cobb-Douglas utility parameterization of the model is a good starting point (Table 2). With $\sigma_{x,h}$, $\sigma_{xh,leisure}$, and $\sigma_{xhl,quality}$ each equal to 1, individuals devote a constant share of their implicit income to each of the four sources of utility. For example, leisure hours remain constant. The increased demand for leisure due to rising wealth is exactly offset by the increased price of leisure (i.e., the real wage). Less obviously, wages and house prices rise at exactly the right rates to capitalize the increased valuation of consumption amenities without any change in relative population.

More specifically, the 1 percent rate of traded-good TFP growth implies 1.5 percent growth of traded-good-denominated wages in both economies.[8] Hence, the city-economy wage discount from its higher quality of life also grows at 1.5 percent. Similarly, traded-good-denominated per-capita housing expenditure grows at 1.5 percent a year in both economies.[9] Therefore, the city-economy house-price expenditure premium from its higher quality of life also grows at 1.5 percent. Finally, 1.5 percent is exactly the rate at which individuals' traded-good valuation of $quality_s$ over $quality_l$ increases. As a share of explicit consumption, $\widetilde{CV}$ remains constant at the assumed initial 5 percent.

The zero migration under the Cobb-Douglas specification reflects a perfect balancing of the desire to use rising traded-good denominated wages to consume more of each of the four sources of utility. In contrast, under the baseline parameterization—with $\sigma_{x,h}$, $\sigma_{xh,leisure}$, and $\sigma_{xhl,quality}$ each equal to 0.5—a stronger desire to increase amenity consumption requires a larger compensating differential (lower wages and higher house prices) in the city economy. This larger compensating differential can only be supported at an increased relative

[8]The corresponding numbers reported in Tables 2, 3, and 4 are instead deflated by the national-economy consumption price index in order to match empirical measures.

[9]The house-expenditure increase decomposes into a 1.2 percent rise in price plus a 0.3 percent increase in quantity per capita.

population density.

The model's greatest sensitivity is with respect to the elasticity of substitution with amenities, $\sigma_{xhl,quality}$ (Table 2, parameterizations 11 and 12). Decreasing the willingness of individuals to trade off with consumption amenities by lowering $\sigma_{xhl,quality}$ below its baseline value considerably increases the strength of this migration. With $\sigma_{xhl,quality}$ equal to 0.25, migration into the city economy occurs at a 1.9 percent annual rate, approximately the same as experienced by San Diego and Tampa, but still somewhat below the growth rate of Miami. Conversely, increasing individuals' willingness to substitute with amenities can reverse the migration. With $\sigma_{xhl,quality}$ equal to 1, individuals exit the city economy at a 0.2 percent annual rate. In this latter case, individuals prefer to cut back on their consumption of amenities in order to increase their consumption of the traded good, housing, and leisure.

Since no independent empirical evidence informs the choice of $\sigma_{xhl,quality}$, the position taken herein is simply to acknowledge the arbitrariness of its baseline value (0.5) and then to recognize that increases from this baseline slow and may even reverse migration to cities with high quality of life while decreases from the baseline speed such migration. Matching observed growth rates simply by varying $\sigma_{xhl,quality}$ will be considered an extremely fragile result.

Migration's other main parameter sensitivities concern the importance of land and housing. Land is the model's only source of congestion, and housing is the more land-intensive of the two goods. Decreasing the ability to substitute between land and the capital-labor intermediate input in the production of housing dampens migration by increasing the cost of the associated crowding (parameterization 6). Increasing land's share of housing factor income similarly dampens migration (parameterization 4). On the consumption side, decreasing the willingness to trade off between the traded good and housing—that is, lowering $\sigma_{x,h}$—also dampens migration to the city economy, where housing prices are higher (parameterization 8).

So far, only the parameterization setting $\sigma_{xhl,quality}$ equal to 0.25 comes close to matching the high observed population growth rates. A relevant question is whether there is any other change in assumptions that implies such fast growth. The next subsection will show that lower initial equilibrium city-economy population density, achieved by assuming lower initial city-economy productivity, can indeed match fast growth. Before proceeding, I briefly discuss some alternative assumptions that fail to do so.

One possibility for achieving faster city-economy population growth is to assume productivity growth that is higher than under the baseline calibration. However, speeding technological progress to 1.25 percent per year (and hence real wage growth to 1.7 percent per year) only increases migration to 0.4 percent per year (Table 3, assumption 1). Instead, there may also be some TFP growth in the provision of housing services, which would make it easier for the city economy to absorb an expanding population. For example, Gort, Greenwod, and Rupert (1999) find that technological progress in construction may be as high as two-fifths of that of traded goods. But even allowing for housing TFP growth at a 0.4 percent rate increases average annual migration only to 0.5 percent (Table 3).

Another possibility for achieving faster migration is to assume that consumption amenities are indeed a luxury good. As discussed in the previous section, the baseline assumes homothetic utility. Allowing, instead, for a minimum threshold of consumption of housing or the traded good or both (i.e., Stone-Geary preferences) implies that demand for consumption amenities will rise considerably faster than does income. For example, h in (4a) can be replaced by $\widetilde{h} \equiv h - h_{min}$. Assuming that the minimum housing consumption threshold, h_{min}, accounts for one half of national-economy housing consumption in 1950 implies an average annual migration rate of only 0.5 percent (Table 3, assumption 3).[10] This assumption, in addition boosting the income elasticity of demand for quality of life above one, also significantly depresses the income elasticity of demand for housing. As a result, the city economy's high housing price less deters immigration.[11] Additionally allowing for minimum traded-good consumption such that it too accounts for one half of national-economy traded-good consumption in 1950 further increases the rate of migration to 0.8 percent (Table 3, assumption 4), which is still well below the observed fast growth rates.

A third possibility for achieving faster city growth is to assume that the city economy's consumption amenities are higher than under the baseline. But even doubling the initial willingness to pay for $quality_c$ to 10 percent of national-economy income only boosts annual population growth to 0.5 percent (Table 3, assumption 5).

[10] A possible motivation for the assumed threshold is that the U.S. Census Bureau's official poverty threshold in 1959 was approximately one half of median family income in that year.

[11] Under the baseline assumptions, the income elasticity of housing demand is 1. Under this alternative, it is approximately 1/2 in 1950 and rises to approximately 3/5 in 2000. These elasticities are calculated based on a choice between the the traded good and housing at the price and income level for each economy in a given time period.

A fourth possibility for achieving faster city growth is to assume that places with high initial quality of life also experience positive growth in quality of life.[12] Shapiro (2006) argues that high-human-capital individuals demand high levels of consumption amenities thereby causing an increase in the supply of such amenities. The increase in supply in turn drives population growth. Waldfogel (2006) documents a causal empirical relationship from local demand for restaurants to restaurant entry. To match the fastest observed relative city-economy population growth rates, the rate of city-economy amenity growth has to be large. For example, a doubling of $quality_c$ between 1950 and 2000 achieves an annual growth rate of 1.6 percent, which is still well below the relative growth rates of San Diego, Tampa, and Miami (Table 3, assumption 6).[13] Matching Miami's 2.6 percent annual relative growth rate requires $quality_c$ to triple between 1950 and 2000 (Table 3, assumption 7).

A final possibility is that endogenously increasing productivity reinforces the amenity-induced migration to the city economy. Evidence suggests that density increases total factor productivity with an elasticity between 0.02 and 0.05 (Ciccone and Hall, 1996; Ciccone, 2002; Combes, Duranton, and Gobillon, 2004). The non-time-dependent component of traded-good TFP in (3a) is therefore assumed to be characterized by

$$\widetilde{\mathrm{A}}_{X,c} = \left(\frac{N_c/D_c}{N_n/D_n}\right)^{\upsilon_X} \tag{6}$$

To the extent that the city economy grows faster than the national one, so too will its traded-good TFP.

Allowing for such increasing returns to scale actually slows migration to the city economy (Table 3, assumptions 8 and 9). The reason is that agglomeration increases the city economy's *initial* equilibrium relative density. Under the baseline, which assumes that productivity is always equal between the two economies, the city economy's higher consumption amenities cause it to have an initial equilibrium density of 1.96. With υ_X equal to 0.02, agglomeration reinforces the higher equilibrium density from the amenities causing initial equilibrium density to be 2.26. With υ_X equal to 0.05, initial equilibrium density is 3.12. The higher initial density levels associated with agglomeration require larger increases in

[12] Positive growth in quality of life is meant to denote an increase in $quality_c$ over time rather than to just an increase in the valuation of a fixed $quality_c$.

[13] Such a "doubling" denotes an increase in $quality_c$ from the level associated with a 5 percent $\widetilde{CV}$ in 1950 to the level associated with a 10 percent $\widetilde{CV}$ in 1950. With the increased valuation of a fixed level of amenities, the total increase in valuation is to $\widetilde{CV}$ equals 17 percent in 2000.

the valuation amenities to achieve a given increase in density. This reflects that the positive elasticity of required quality of life with respect to density has a positive first derivative (Rappaport 2008a). In the present case, the negative effect on city population growth from the higher initial density dominates the faster growth that arises due to agglomerative increases in productivity from the migration to high quality of life.

This last example suggests that allowing for lower initial city-economy equilibrium density may considerably boost migration. The second subsection below shows that this is indeed the case. First, however, the next subsection describes the decreasing importance of local productivity in choosing where to live.

4.4 The Decreasing Importance of Local Productivity

The migration to high quality of life described above arises because the marginal utility of goods consumption falls relative to the marginal utility of amenities consumption. Under the baseline parameterization, technological progress is assumed to occur just for the traded good and not for housing. As a result, the marginal utility of traded goods falls relative to housing as well. People are thus willing to sacrifice an increasingly large amount of traded goods for housing.

Consider two city economies, each with a level of amenities identical to that of the national economy. One of the two has traded-good TFP below that of the national economy such that its initial equilibrium relative population density is 1/3. The other has traded-good TFP above that of the national economy such that its initial relative density is 3. As illustrated in Figure 1, assumed faster technological progress in the traded-good sector causes national-economy housing prices to rise. As their wealth increases, people desire to increase their consumption of housing. Low-density places, with their lower housing prices, become increasingly desirable notwithstanding their lower relative traded-good productivity. Productivity becomes less important as a source of locational advantage.

As a result, places with different traded-good productivity but identical housing productivity and identical consumption amenities converge in equilibrium population density (Figure 4). When the only underlying fundamental difference across cities is traded-good productivity, all cities eventually asymptote to a relative density of 1. To be sure, such convergence is quite slow. Under the baseline parameterization and assumptions, it takes approximately 100 years for equilibrium population density to close half the log gap to its asymptotic value. Nevertheless, average annual growth over the first 50 years of 0.7 percent by the low-productivity city and average growth over the first 50 years by the high-productivity city of -0.6 percent are quantitatively important.

Two alternative assumptions concerning housing partly dampen the allure of the low-productivity economy. A first such assumption is positive technological progress in the provision of housing services. As housing productivity growth increases (in both economies), migration into the low-productivity economy falls.[14] The intuition is that increased housing production can better satisfy the consumption demands of high-productivity-economy residents. A second alternative assumption is non-homothetic preferences with an income elasticity for housing that is less than one, as suggested by some estimates (e.g., Goodman, 1988, 1990; Wihelmsson, 2002). In this case, the increase in demand for housing is smaller than under the baseline.

The decreasing importance of local traded-good productivity differences is distinct from the increasing importance of local amenity differences. After all, the convergence in population density just described occurs among places with equal quality of life. However, the two trends complement each other to fuel the growth of low-productivity, high-amenity cities.

4.5 Variations in Both Productivity and Quality of Life

Among city economies with identical levels of amenities, population growth is inversely correlated with initial equilibrium density. One reason, as just described, is the decreasing importance of the productivity differences that underpin the initial density differences. A separate reason is the greater ease with which low-density localities can absorb population increases. To achieve fast population growth requires both low initial density and high amenities.

Initial population densities of the hypothesized high-amenity metro areas vary greatly. Measured by the population and land area in 1950 of the largest municipality in each metro area, relative density ranged from 0.35 for San Diego up to 2.58 for New York City (Table

[14]Even with equal technological progress in both sectors, there is still some migration into the low-productivity economy. The reason is the greater constraint on production in the high-density economy from the fixed stock of land.

4).[15] For these nine cities, metro-area growth is indeed negatively correlated with initial municipal density.

For low-productivity but high-amenity economies, the decreasing importance of productivity and increasing importance of quality of life complement each other. Consider four city economies with high consumption amenities. Specifically, let initial $\widetilde{CV}$ equal 0.05 for each of them, and let initial traded-good TFP be such that one has an initial equilibrium relative density of 1/3 (low), one has an initial equilibrium relative density of 1 (unitary), the third has an initial relative density of 3 (high), and the fourth has an initial density of 6 (very high).

As in the previous subsection, there is convergence under the baseline parameterization and set of assumptions (Table 4, simulations 1 to 4). The low-density city economy grows at an average 1.9 percent rate from 1950 to 2000 whereas the high-density city economy grows at a -0.4 percent rate. Over time, equilibrium population densities of economies with identical quality of life but differing productivity converge towards each other (Figure 5). Unlike in the previous subsection, the density to which the high amenities converge is itself very gradually rising over time. However, to see this upward slope requires a time horizon of several centuries. As is intuitive, increasing an economy's amenities shifts upward the implicit density time path to which it converges.

Average growth of the low-density economy is still slightly slow compared to the fastest empirical growth rates. Several plausible alternative assumptions cause growth to be considerably faster. One such alternative is to assume that traded-good productivity increases with density (Table 4, simulations 5 to 8). Letting υ_X equal 0.035 (halfway between the low and high estimates described in the previous section), the low-density economy achieves an average relative growth rate of 2.7 percent, thus matching the fastest of the observed growth rates. The high-density economy achieves an average growth rate of -0.5 percent, thus approximately matching the observed negative growth rates.

An alternative boost to average growth comes from assuming that amenities are a luxury

[15]The normalization for these densities is the median density as experienced by all persons living in municipalities with a 1950 population of at least fifty thousand. Municipal population densities generally decreased between 1950 and 2000 due the annexation of land and suburbanization. As a result, the *relative* population densities of Boston, New York, and San Francisco all increased. The relative population growth rates in the table pertain to the entire metro area.

good (Table 4, simulations 9 to 12). Assuming minimum thresholds to traded and housing consumption equal to one half of their 1950 large-economy level implies average growth for the low-density economy of 3.0 percent. As is also the case under the baseline and agglomeration assumptions, the four economies converge towards an upwardly-sloped long-run density time path (Figure 6). With amenities as a luxury, this long-run time path rises more quickly than when utility is homothetic. Even so, the long-run upward slope is gradual, rising at approximately 0.3 percent per year in 2050 and thereafter decelerating to 0.1 percent approximately 300 years later.

Notwithstanding upwardly-sloped long-run density paths, the fast growth rates of the low-density, high-amenity economies eventually taper off. Under the baseline set of assumptions, the growth rate of the low-density economy slows from 2.3 percent in 1950 to 1.5 percent in 2000 to 0.9 percent in 2050. Under the increasing-returns assumption, growth slows from 5.9 percent in 1950 to 1.4 percent in 2000 to 0.7 percent in 2050. Conversely, economies with initial equilibrium population density sufficiently above the implicit long-run path experience negative population growth that eventually tapers. Such negative growth is despite that such economies have both high amenities and high productivity. The model can thus replicate the relative population decline of places such as New York, Boston, and San Francisco.[16]

The modeled house-expenditure growth rates of the less-dense economies are broadly consistent with the house-expenditure relative growth experienced by the hypothesized high-amenity economies. Under the baseline, increasing returns, and luxury goods assumptions, house expenditure relative growth for the low- and unitary-density economies ranges from 0.2 percent (base assumptions, unitary economy) up to 0.9 percent (luxury goods, low-density economy). The expenditure growth rates of four of the six high-amenity metros with initial density below one fall within this range.

Less clear is whether the modeled house-expenditure relative growth of the higher-density economies is consistent with observed growth. Under the various assumptions above, house-expenditure relative growth by the high- and very-high density city economies is close to zero, which is consistent with the experience of New York. But the two other high-

[16]Negative *relative* population growth by high-density economies is significantly strengthened if the system of national and city economies experiences joint population growth. High density makes it difficult to absorb new residents.

density economies, Boston and San Francisco, had substantially higher expenditure growth. Even with numerous supplemental assumptions–including constraints on house supply as in Glaeser, Gyourko, and Saks (2005, 2006)–the model can not replicate even moderate house-expenditure growth.[17] This failure reflects high-density economies' relative population decline, which puts strong downward pressure on house prices.

A different possible inconsistency between the model and empirics is the low level of relative wages in the city economies. Such low wages integrally compensate for high amenities. But among the nine hypothesized high-amenity metro areas in 2000, only Tampa had a relative wage below one (Table 4). Four of the metro areas had relative wages slightly above one; four had relative wages well above one. In contrast, neither of the lower-density economies comes close to attaining a relative wage of one, regardless of supplemental assumptions. And only the very-high-density economy, which has a traded good productivity advantage of approximately 17 percent, comes anywhere close to matching the highest observed wages.

A possible reconciliation of the model with observed growth rates would be to allow for sorting. If, similar to Gyourko, Mayer, and Sinai (2006), high-skilled individuals disproportionately move to high-amenity metro areas, those areas would experience faster home price appreciation. Lee (2005) presents empirical evidence consistent with such sorting. Measured wage growth in high-amenity economies would quicken for two reasons. Most obvious is the increasing share of the high-amenity population earning high-skilled wages. In addition, low-skilled individuals would require faster wage growth to compensate for the portion of house-price appreciation induced by sorting. Alternatively, all low-skilled individuals might leave high-amenity areas.

5 Conclusions

A general-equilibrium model suggests that broad-based technological progress induces migration towards areas with high quality of life. The result is sensitive to the assumed elasticity of substitution with quality of life but is otherwise robust. Under a baseline parameterization and set of assumptions, a high-quality-of-life city—one with amenities for which individuals would initially be willing to pay 5 percent of their income—grows slightly faster than an

[17] Housing supply constraints can be modeled by dampening either the level or growth rate of housing productivity in the city economy.

otherwise identical locality.

The endogenous migration to high-amenity cities is considerably strengthened by low initial density underpinned by low relative productivity. Under the baseline parameterization and set of assumptions, a high-amenity city economy with an initial equilibrium relative density of 1/3 grows almost 2 percentage points faster than the national economy. Allowing for agglomerative productivity or letting amenities be a luxury good considerably speeds this move towards high quality of life. Conversely, a high-amenity city economy with high initial density underpinned by high relative productivity can experience negative relative population growth.

Complementing the increasing importance of quality of life is the independent decreasing importance of productivity. Technological progress in the production of traded goods increases demand for housing. And so the low house prices in low-productivity cities become an increasing draw.

Asymptotically, amenities are the sole determinant of population density. The population densities of cities with identical amenities but different productivity eventually converge to each other.

A key weakness of the model is the assumption that a city economy, interpreted as a metropolitan area, has fixed land area. Of course, this is essentially never the case. But this counter-factual assumption does not undermine the model's basic result. Broad-based technological progress increases demand for amenities, even with homothetic utility. This increased demand, in turn, induces migration towards high-amenity places, even when such places can not geographically expand to accommodate the inflow. This migration towards high quality of life should continue well into the future.

The model suggests that the best chance for slow-growth metropolitan areas to attract new residents and firms is to improve their quality of life. Acquiring nice weather or a coastal location may not be options. But the alternative of subsidizing firms may be ineffective. Policies to improve quality of life might focus on a wide array of consumer and civic amenities. Some possibilities include schools, public health and safety, public and private transit, clean air, parks, libraries, museums, zoos, the arts, sports teams, festivals, and more. Many of the determinants of quality of life are poorly understood. Many metropolitan governments may nevertheless feel they have no choice but to search for them.

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Table 1
Baseline and alternative calibrations

Parameter	Base	Low Resistance ("Loose")[1,2]	High Resistance ("Tight")[1,2]
Land Factor Income Share[3] (national economy)			
Traded Good:	**1.6%**	0.4%	4.8%
Housing:	**35%**	20%	50%
Housing Production CES ($\sigma_{D,KL}$)	**0.75**	1	0.50
Required Capital Rent (r_K)	**0.08**		
Utility CES Parameters			
$\sigma_{x,h}$	**0.50**	0.75	0.25
$\sigma_{xh,leisure}$	**0.50**	1	0.25
$\sigma_{xhl,quality}$	**0.50**		
Consumption Expenditure Shares (national economy)			
Housing	**18%**	14%	22%
Leisure (share of time)	**35%**	20%	50%

[1]More "resistance" implies a larger difference in quality of life or productivity is required to support an arbitrary difference in population density.
[2]The CES substitution parameters ($\sigma_{D,KL}$, and $\sigma_{x,h}$) have an asymmetric effect on resistance. The "loose" values above are those for which resistance is lower at a relative density of one and above.
[3]Non-land factor income is divided between capital and labor on a one-third to two-thirds basis both for the traded good and for housing.

Table 2
Alternative Parameterizations

Metro Area and Parameterization	Nationl Econ. annual growth, 1950 to 2000		City Economy annual growth, 1950 to 2000			
	w_n/P_n	$(p_nh_n)/P_n$	pop_c/pop_n	CV/P_n	p_c/p_n	$(p_ch_c)/(p_nh_n)$
Empirical						
Aggregate U.S.	1.5%	-	·	·	·	·
Medium & Large Metro Avg.	-	1.6%	·	·	·	·
Miami	·	·	2.6%	-	-	-0.3%
Tampa	·	·	2.1%	-	-	-0.3%
San Diego	·	·	1.9%	-	-	0.8%
Denver	·	·	1.3%	-	-	0.4%
Los Angeles	·	·	0.7%	-	-	0.7%
Seattle	·	·	0.6%	-	-	0.9%
San Francisco	·	·	-0.1%	-	-	1.3%
Boston	·	·	-0.7%	-	-	0.7%
New York	·	·	-0.7%	-	-	0.1%
Baseline	1.3%	1.7%	0.3%	2.2%	0.3%	0.1%
Cobb Douglas Utility	1.4%	1.4%	0.0%	1.4%	0.0%	0.0%
Traded-Good Factor Shares						
1. D=0.4%, K=33.2%, L=66.4%	1.3%	1.7%	0.2%	2.2%	0.2%	0.1%
2. D=4.8%, K=31.7%, L=63.5%	1.3%	1.7%	0.4%	2.2%	0.2%	0.1%
Housing Factor Shares						
3. D=20%, K=26.7%, L=53.3%	1.4%	1.6%	0.6%	2.3%	0.3%	0.1%
4. D=50%, K=16.7%, L=33.3%	1.3%	1.8%	0.2%	2.2%	0.2%	0.1%
Housing Production CES						
5. $\sigma_{D,KL} = 1$	1.3%	1.7%	0.6%	2.2%	0.2%	0.1%
6. $\sigma_{D,KL} = 0.50$	1.3%	1.7%	0.1%	2.2%	0.3%	0.1%
Utility CES, Traded & Housing						
7. $\sigma_{x,h} = 0.75$	1.4%	1.4%	0.7%	2.3%	0.4%	0.1%
8. $\sigma_{x,h} = 0.25$	1.3%	2.0%	0.1%	2.2%	0.1%	0.1%
Utility CES, with Leisure						
9. $\sigma_{xh,leisure} = 1$	1.3%	1.9%	0.2%	2.4%	0.2%	0.1%
10. $\sigma_{xh,leisure} = 0.25$	1.3%	1.6%	0.4%	2.2%	0.3%	0.1%
Utility CES, with Quality of Life						
11. $\sigma_{xhl,quality} = 1$	1.3%	1.7%	-0.2%	1.3%	-0.1%	0.0%
12. $\sigma_{xhl,quality} = 0.25$	1.3%	1.7%	1.9%	3.8%	1.2%	0.5%
Housing Expenditure Share						
13. $p_nh_n/(x_n+p_nh_n) = 0.08$	1.4%	1.8%	0.4%	2.3%	0.3%	0.1%
14. $p_nh_n/(x_n+p_nh_n) = 0.16$	1.2%	1.6%	0.2%	2.1%	0.2%	0.1%
Leisure Share of Time						
15. $leisure_n = 0.14$	1.3%	1.8%	0.4%	2.4%	0.3%	0.1%
16. $leisure_n = 0.42$	1.3%	1.6%	0.3%	2.1%	0.2%	0.1%

Dots signify cells that are not applicable; dashes signify missing data. Medium and large metro housing expenditure growth rate is based on the population-weighted growth of the real median value of owner-occupied housing for the 132 metro areas with a populaton of at least 150,000 in 1950. Relative growth for the nine specific cities is relative to aggregate population growth for these medium and large metro areas. Median house values in 1950 and 2000 are based on the respective decennial census. All parameterizations differ from baseline only as explicitly listed.

Table 3
Alternative Assumptions

Parameterization	Nationl Econ. annual growth, 1950 to 2000		City Economy annual growth, 1950 to 2000	
	w_n/P_n	$(p_n h_n)/P_n$	pop_c/pop_n	$(p_c h_c)/(p_n h_n)$
Baseline	1.3%	1.7%	0.3%	0.1%
TFP Growth				
1. $\gamma(A_X) = 1.25\%$	1.7%	2.1%	0.4%	0.1%
2. $\gamma(A_H) = 0.40\%$	1.4%	1.5%	0.5%	0.1%
Minimum Consumption				
3. $h_{L,min}/h_L(0) = ½$	1.4%	1.4%	0.5%	0.2%
4. $h_{L,min}/h_L(0)$, $x_{L,min}/x_L(0) = ½$	1.3%	1.6%	0.8%	0.3%
Higher Consumption Amenities				
5. CV(0) = 0.10	1.3%	1.7%	0.5%	0.2%
Amenity Growth				
6. $quality_c$ doubles[1]	1.3%	1.7%	1.6%	0.4%
7. $quality_c$ triples[1]	1.3%	1.7%	2.6%	0.7%
Endogenous TFP				
8. $\upsilon_X = 0.02$	1.3%	1.7%	0.2%	0.1%
9. $\upsilon_X = 0.05$	1.3%	1.7%	0.0%	0.0%

[1] A "doubling" of $quality_c$ connotes an increase in $quality_c$ such that its *initial* relative valuation increases from 5 percent to 10 percent. A "tripling" connotes an increase to 15 percent.

Parameterizations differ from baseline only as explicitly listed.

Table 4
Alternative Initial Conditions

Metro or Assumptions	City Economy					
	value in 1950		avg. growth		value in 2000	
	density (munic.)	$(p_c h_c)/(p_n h_n)$	pop_c/pop_n	$(p_c h_c)/(p_n h_n)$	$(p_c h_c)/(p_n h_n)$	w_c/w_n
EMPIRICAL						
Miami	0.75	1.05	**2.6%**	-0.3%	0.99	1.02
Tampa	0.68	0.77	**2.1%**	-0.3%	0.72	0.83
San Diego	0.35	1.09	**1.9%**	0.8%	1.74	1.02
Denver	0.64	1.04	**1.3%**	0.4%	1.36	1.05
Los Angeles	0.45	1.14	**0.7%**	0.7%	1.75	1.26
Seattle	0.68	0.93	**0.6%**	0.9%	1.56	1.09
San Francisco	1.79	1.30	**-0.1%**	1.3%	2.69	1.42
Boston	1.73	1.10	**-0.7%**	0.7%	1.65	1.15
New York	2.58	1.40	**-0.7%**	0.1%	1.61	1.27
CITY ECONOMY WITH CV(0)/Y(0) = 0.05						
Equal TFP ($A_{X,c}=A_{X,n}$)	1.96	1.14	**0.3%**	0.1%	1.20	0.97
Alternative TFP (Exogenous)						
1. $A_{X,c}$ s.t. initial density = ⅓	0.33	0.70	**1.9%**	0.3%	0.80	0.82
2. $A_{X,c}$ s.t. initial density = 1	1.00	0.91	**0.9%**	0.2%	1.00	0.90
3. $A_{X,c}$ s.t. initial density = 3	3.00	1.35	**0.0%**	0.0%	1.38	1.04
4. $A_{X,c}$ s.t. initial density = 6	6.00	1.89	**-0.4%**	-0.1%	1.83	1.21
Alt TFP with increasing returns						
5. υ_X= 0.035, $den_s(0)$ = ⅓	0.33	0.70	**2.7%**	0.6%	0.92	0.86
6. υ_X= 0.035, $den_s(0)$ = 1	1.00	0.91	**1.1%**	0.3%	1.06	0.92
7. υ_X= 0.035, $den_s(0)$ = 3	3.00	1.35	**0.0%**	0.0%	1.38	1.04
8. υ_X= 0.035, $den_s(0)$ = 6	6.00	1.89	**-0.5%**	-0.1%	1.79	1.19
Alt TFP, min consumption of h and x						
9. min consump, $den_s(0)$ = ⅓	0.33	0.61	**3.0%**	0.9%	0.94	0.80
10. min consump, $den_s(0)$ = 1	1.00	0.91	**1.5%**	0.6%	1.20	0.89
11. min consump, $den_s(0)$ = 3	3.00	1.76	**0.3%**	0.1%	1.86	1.08
12. min consump, $den_s(0)$ = 6	6.00	3.65	**-0.2%**	-0.2%	3.24	1.46

Empirical density in 1950 pertains to largest municipality in metro area. All other empirical variables pertain to entire metro area. Growth rates are averages from 1950 to 2000.

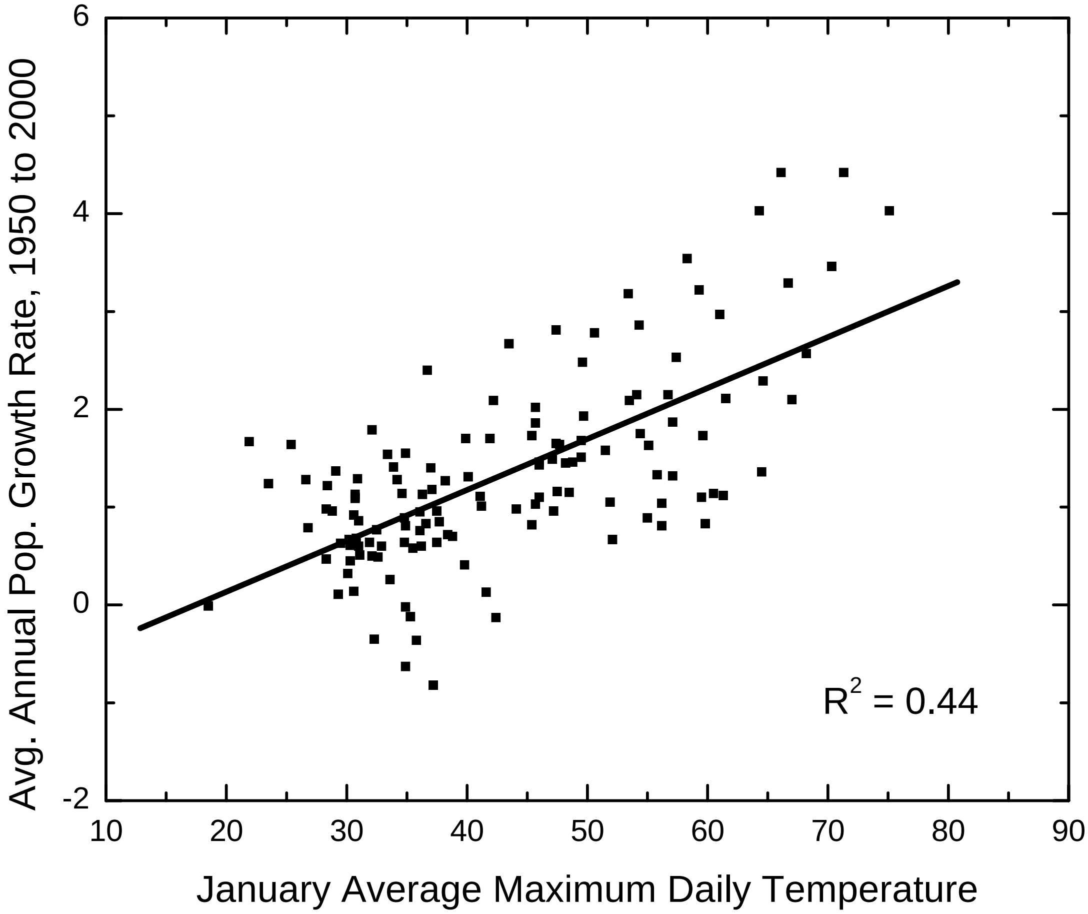

Figure 1: January temperature and metro area average annual growth, 1950 to 2000. Metro areas based on 2003 CBSA definitions limited to metros with 1950 population of at least 150,000.

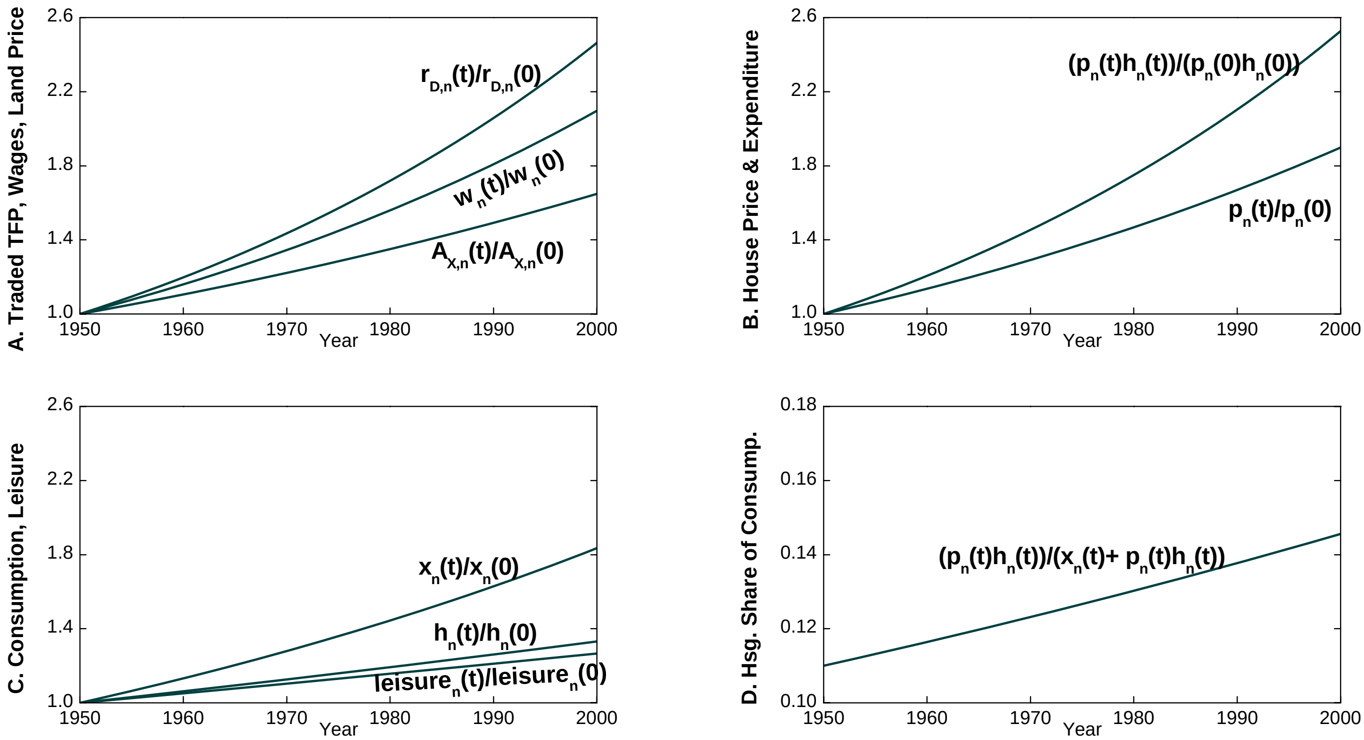

Figure 2: Baseline national-economy dynamics. Evolution over time of equilibrium outcomes in the national economy under the baseline parameterization and set of assumptions.

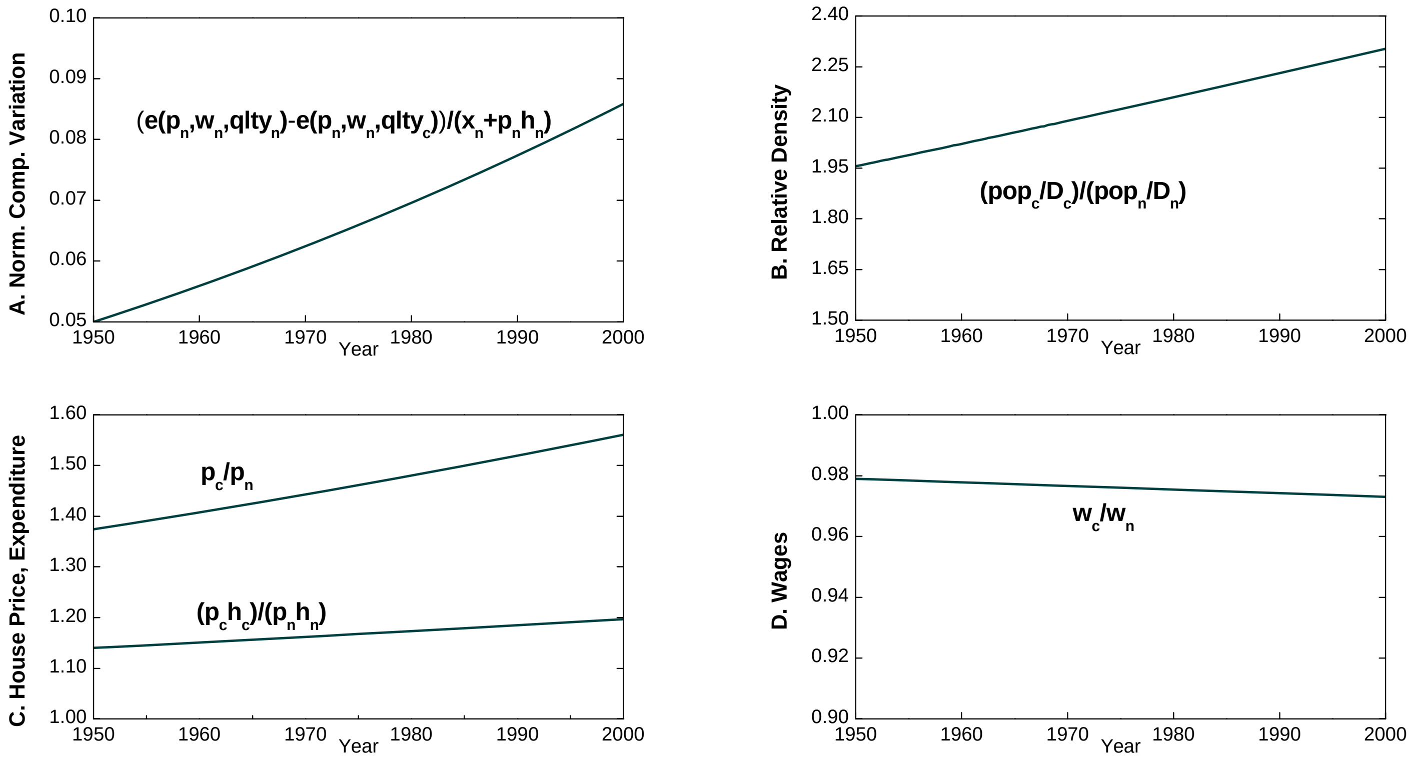

Figure 3: Baseline city-economy dynamics. Evolution over time of equilibrium outcomes in the city economy under the baseline parameterization and set of assumptions.

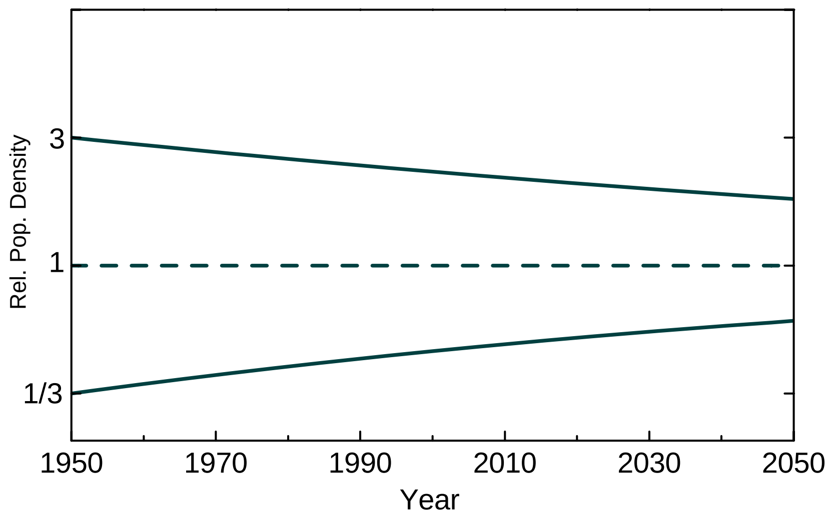

Figure 4: Convergence of equilibrium population density of city economies with amenities equal to those of the national economy but with different levels of productivity. Figure uses the the baseline parameters.

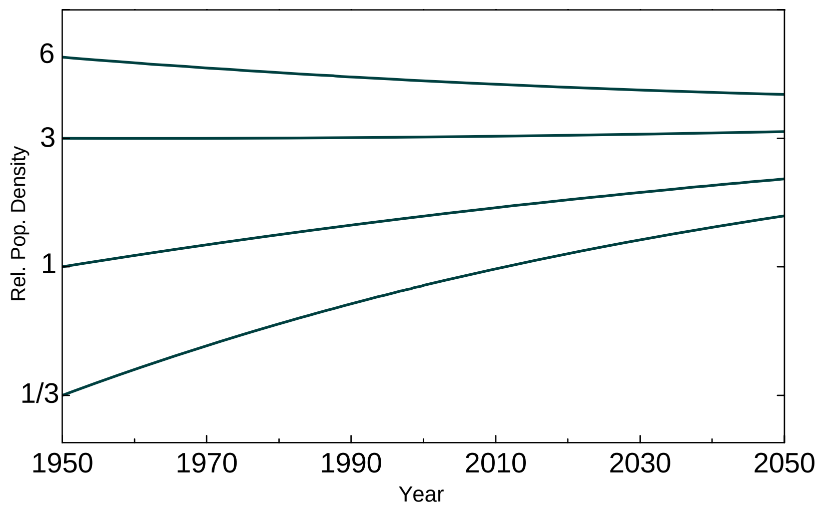

Figure 5: Convergence of equilibrium population density of city economies with identical high amenities but different levels of productivity. Baseline parameters. Amenities are initially valued at 5 perecent of large-economy income.

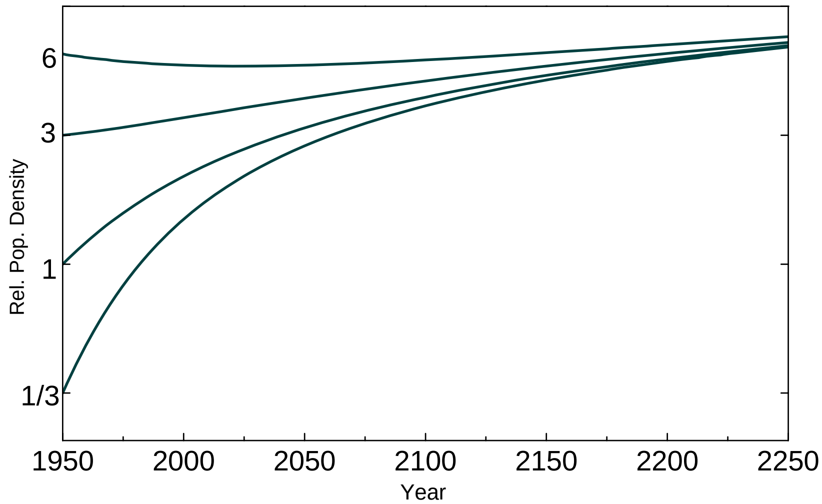

Figure 6: Very-long-run convergence of high-amenity economies when amenities are a luxury good. Minimum goods consumption accounts for half of initial goods consumption. Amenities are initially valued at 5 percent of large-economy income.