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The settlement of the United States, 1800–2000: The long transition towards Gibrat's law ☆

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ABSTRACT

Gibrat's law, the orthogonality of growth with initial levels, has long been considered a stylized fact of local population growth. But throughout U.S. history, local population growth has significantly deviated from it. Across small locations, growth was strongly negatively correlated with initial population throughout the nineteenth and early twentieth centuries. This strong convergence gave way to moderate divergence beginning in the mid-twentieth century. Across intermediate and large locations, growth became moderately positively correlated with initial population starting in the late nineteenth century. This divergence eventually dissipated but never completely. A simple-one sector model combining the entry of new locations, a friction from population growth, and a decrease in the congestion arising from the supply of land closely matches these and a number of other evolving empirical relationships.

1. Introduction

Gibrat's law, the orthogonality of growth and initial levels, has long been considered a stylized fact of local population growth (Glaeser et al., 1995; Eaton and Eckstein, 1997; Ioannides and Overman, 2003). This orthogonality is often interpreted as implying that growth is random in the sense that the distribution of local population is not pinned down by exogenous determinants of productivity and quality of life. Orthogonal growth is also frequently cited as an asymptotic explanation for the observed log normal distribution of population across locations and, in the presence of a lower bound on city size, for the observed Zipf's distribution of cities (Eeckhout, 2004; Gabaix, 1999).

In this paper we analyze growth across all counties and metros throughout the entirety of U.S. history and reject that Gibrat's ever held. Instead we find that population growth was strongly negatively correlated with initial population among small locations throughout the nineteenth and early twentieth centuries. This strong convergence gave way to moderate divergence among small locations beginning in the mid-twentieth century, which persisted through 2000. Among intermediate and large locations, population growth also became moderately positively correlated with initial population beginning in the late nineteenth century. This divergence eventually ended among large locations but not among intermediate ones. The U.S. system of locations thus gradually transitioned towards Gibrat's law but never fully attained it.

We hypothesize that the observed convergence of small locations in the earlier period reflects the continual "entry" of new counties into the U.S. system of locations and their subsequent upward transitions to their long-run relative population levels. Over the two hundred years we study, the U.S. continental land area grew from less than 1 million square miles, primarily along the eastern seaboard, to over 7.5 million square miles, coast to coast. Correspondingly, some counties have been settled by Europeans considerably longer than others. We further hypothesize that the observed divergence in the later period represents a decrease in net congestion arising from a shift away from land-intensive production and an increase in the returns to agglomeration. Hansen and Prescott (2002) and Michaels et al. (2012) emphasize the decrease in land congestion associated with the structural transformation away from agriculture during the late nineteenth and early twentieth centuries. Gaspar and Glaeser (1998) and Desmet and Rossi-Hansberg (2009) emphasize

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the increase in the return to agglomeration arising from the introduction of several general purpose technologies during the twentieth century.

The paper documents five salient empirical relationships consistent with these hypotheses. First, locations of similar age since entry exhibit similar growth patterns independent of calendar year. Growth of young locations is *always* characterized by strong convergence. Growth of old locations is *never* characterized by strong convergence. Second, the rapid growth of newly-entered locations quickly dies out: within 20 years for most and within 60 years for all. Third, convergence completely dissipates by 1940, approximately 20 years after the waning of location entry. Fourth, the subsequent divergence among small locations persists through the end of the twentieth century. Fifth, intermediate and large locations begin to diverge among each other around 1880. This divergence soon ends among the largest locations but persists through 2000 among the intermediate locations.

Informed by these salient relationships, we develop a simple one-sector general equilibrium model of a system of locations that evolves due to entry, decreasing net congestion, and chance. At first only a small share of locations are actually occupied. Over time, the remainder exogenously enter with low initial population. Frictions on positive population growth slow upward transitions and so cause growth from low levels to be characterized by convergence. Overlapping this extended period of entry, net congestion gradually diminishes and so long-run relative population levels become more sensitive to underlying differences in productivity. This introduces a force towards divergence. Once entry is complete and the degree of net congestion stabilizes, the system soon approaches Gibrat's law.

A simulation of the model with just a handful of free parameters tightly matches each of the five evolving empirical relationships described above as well as a number of other evolving relationships. Most model parameters are pinned down to match a specific empirical moment such as aggregate U.S. population and the number of active counties in each decennial census year. Only four parameters retain any freedom to endogenously match more than fifty empirical relationships. These relationships include the distribution of population levels in eleven benchmark years, the distribution of population growth rates over ten twenty-year intervals, the nonlinear correlation between initial population and population growth for ten twenty-year periods, the high persistence of population growth over nine adjacent pairs of twenty-year periods, and the sixty-year growth trajectories of three entering cohorts of locations. Many of these empirical relationships are also matched for young and old sub-samples of locations.

This tight match to a rich set of empirical relationships suggests that the model captures key contours that shaped the system of U.S. locations as it evolved. As with all economic models, ours abstracts from numerous important considerations and developments. Examples include canals, steamships, railroads, the Civil War, electrification, immigration, and the automobile. Each of these played pivotal roles in determining the specific geographical location of U.S. economic activity. But much of the essence that drove overall local growth patterns can be understood in our simple framework.

We are not the first to question Gibrat's law in the context of local development. Michaels et al. (2012) also document a strong positive correlation of growth with population from 1880 to 2000. We differ from them by emphasizing the role of entry and by focusing on the gradually evolving relation between growth and size over the last two centuries. In particular, we find that the changing age composition of locations is a key driver of the evolving balance of convergence and divergence dynamics since 1800. Other papers that have questioned Gibrat's law include Beeson and DeJong (2002), who document the especially rapid population growth by U.S. states following their admission to the union; Holmes and Lee (2010), who divide the U.S. into a grid of six-by-six mile squares and find an inverted-U relation between growth and size from 1990 to 2000; and Dittmar (2011), who shows that orthogonal growth across European cities emerged only in the modern period, after 1500.

These rejections imply that orthogonal population growth cannot be the proximate cause of the level distribution of population across U.S. locations, whether Zipf's or log normal. Consistent with this conclusion, we document that the distribution of population across U.S. counties was already log normal in 1790, an early date to achieve an asymptotic outcome. An interpretation more in line with our findings is that the distribution of local population depends on the unobserved distribution of local productivity and quality of life (Krugman, 1996; Davis and Weinstein, 2002; Rappaport and Sachs, 2003). In a frictionless setting, with a sufficient number of stochastic determinants of local population, the distribution of population will be log normal (Lee and Li, 2013). If these stochastic determinants evolve orthogonally, the population distribution will evolve orthogonally as well. But following entry and other large shocks, frictions can cause population to significantly differ from its long-run distribution and population growth to be correlated with initial population.

Our work is also closely related to the newer literature that analyzes the importance of the age of locations on their growth and size distributions. Sánchez-Vidal et al. (2014) document the faster growth of younger cities in the United States throughout the twentieth century, especially in the first decade following their incorporation. This parallels our finding that the fast-growing small counties throughout the nineteenth and early twentieth centuries were ones that had recently entered the U.S. system. An important endogeneity concern is that counties may enter and cities incorporate when their geographical location has recently been experiencing fast population growth. To address this possible bias, we construct counties with borders from forty years prior to the initial year from which growth is measured. Doing so effects nearly identical results. Giesen and Suedekum (2014) emphasize the effect of city age on the long-run distribution of city sizes. In particular, they document a positive correlation between the cities' population in 2000 and their age. Our model is characterized by a similar correlation, but only during the transition of locations towards their long-run relative population levels.

The rest of the paper is organized as follows: Section 2 describes the data. Section 3 documents the salient empirical relationships described above. Sections 4 and 5 lay out the model and calibrate it. Section 6 presents numerical results. A final section briefly concludes.

2. Data

Our dataset is built using data for county and county-equivalents as enumerated in the 1790 through 2000 decennial censuses (Haines, 2005). During the nineteenth and early twentieth centuries, the number of enumerated counties soared from just under 300 in 1790 to more than 3100 in 1940 (Table 1 column 1).[1]

County borders changed considerably over time. Hence, we use a "county longitudinal template" (CLT) augmented by a map guide to decennial censuses to combine enumerated counties as necessary to create geographically-consistent county equivalents over successive twenty-year-periods (Horan and Hargis, 1995; Thorndale and Dollarhide, 1987). For example, suppose county A

[1] Because our focus is on a system of locations among which there is reasonably high mobility, we exclude Hawaii and Alaska from our sample.

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