Convergence in Venture Capital Investments: Evidence from a Panel of 18 US Regions

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Abstract: This empirical study examines the time series properties of U.S. venture capital investments across different geographical markets. Using a battery of panel unit root tests, we find substantial evidence of stochastic convergence in that (relative) venture capital investment shares are stationary. Our findings indicate that venture capital investment shocks are temporary and tend to adjust back to their respective long-run means. These results are supportive of convergence in economic activity as there may be diminishing returns to venture capital. As such, regional policymakers may use historical data to make projections and capital allocation decisions with regards to investment in entrepreneurial activities.

1. Introduction

There is substantial variation in economic growth across different regions (OECD, 2009). Romer (1986) discusses the role of knowledge creation and high-technology clustering as a source of economic growth and explains technological progress as an endogenous component to economic growth. As such, this progress comes from directed actions and investment in human capital, which tends to attract venture capital investments (Mathur, 1999). However, limitations on economic resources can result in diminishing returns to productive activities, leading to convergence in economic growth across regions and time (Barro and Sala-i-Martin, 1991; Higgins et al., 2006). Gittell and Sohl (2005) discuss the different policies to promote high-technology centers to encourage regional economic development. These policies work to facilitate entrepreneurial activity and network effects such as supplier relationships and knowledge spillovers that lead to economic development (Shaw, 1997; Chell and Baines, 2000; Gittell and Sohl, 2005). Venture capital is one such area that regional

economic developers and policymakers pursue to attract investment in various start-up firms.

Entrepreneurs and start-up firms often need infrastructure investment as well as collaborative partners (i.e., suppliers) that encourage clustering in geographical areas (Feldman, 1999; Samila and Sorenson, 2010). Fostering this type of collaboration of entrepreneurial activity may result in additional venture capital funding opportunities (Chen et al., 2010). However, the concentration of such resources, while necessary, is not sufficient for long-term growth (OECD). The growth opportunities may depend on how such investments are utilized (Sleuwaegen and Boiardi, 2014), the geographic proximity of entrepreneurs seeking such investments, and how venture capitalists are clustered around firms in which they have invested (Chen et al., 2010). Clearly, geography plays an even greater role as venture capitalists tend to take a more active role in the companies in which they invest (Lerner, 1995; Mollica and Zingales, 2007). While these factors highlight the need to acquire

capital investments for economic growth, there is still the question of whether such investments in start-up firms vary by region. While investments may vary by region, in order to assist regional economic developers to formulate policy to create opportunities for startups, it is important to understand the market dynamics of venture capital investments.

2. Venture Capital Investment Framework

In order to understand the market dynamics of venture capital investments, we develop a simple reduced-form model of venture capital investments across regions. The basic specification of supply and demand in the venture capital market for a particular region may be represented as:

$$VCI^S = VCI^S(X^S, E(r)) + \mu^S \qquad (1)$$

$$VCI^D = VCI^D(X^D, E(r)) + \mu^D \qquad (2)$$

where X^S and X^D are vectors of exogenous variables that affect the supply and demand for venture capital investments, $E(r)$ is the expected rate of return from such investments, and μ^S and μ^D are shocks to supply and demand that are assumed to have zero mean and are uncorrelated. Thus, the supply of venture capital depends on the expected return relative to other investments, including other regional venture capital investments. The higher the expected return, the greater investors' willingness to supply capital to entrepreneurial (or start-up) firms. Likewise, the number of firms seeking capital depends on the expected rate of return. As the expected rate of return increases, fewer firms can meet those expectations. A region's equilibrium level of venture capital investments, relative to the nation, can be expressed as:

$$VCI^e = VCI^e(X^S, X^D, E(r)) + v \qquad (3)$$

The relative amount of venture capital investments will respond to changes in the exogenous variables that affect both supply and demand in the particular regional market as well as other regions. VCI^e may differ from zero due to regional market differences. For example, there has been considerable literature on the role of economic freedoms on innovation, entrepreneurship, population, migration, and overall well-being. In fact, Stansel (2013) examines U.S. metropolitan areas and finds that higher per capita income and lower unemployment are correlated with higher levels of local economic freedom. Belasen and Hafer (2013) find that the direct relationship between well-being and changes in economic freedom is also impacted by regional variables. Likewise, migration decisions of entrepreneurs may be driven by expected future income (Cebula, 1979), employment opportunities (Partridge and Rickman, 2006), amenities (Cushing, 1987; Cebula, 1993, 2005; Cebula and Payne, 2005), and public policies (Charney, 1993). Venture capital is even more likely to be geographically clustered due to the unique structure of venture capitalists being more involved in the operations of the startups.

While venture capital investments may be geographically concentrated, they may be very mobile. As such, we are interested in examining the time series properties of venture capital investments in the U.S. by modeling the region's relative share, VCI_t, in two parts:

$$VCI_t = VCI^e + \varepsilon_t \qquad (4)$$

The VCI^e represents the time-invariant equilibrium differential and ε_t represents the deviations from equilibrium over time. Since regional deviations in venture capital may come from changes in local demand, specialized institutions, and social networks (Delgado, Porter, & Stern, 2014), we allow the rate of convergence to differ across regions. For example, Monchuk and Miranowski (2010) find that for the U.S. Midwest local innovation positively impacts both employment growth and population growth. Likewise, changes in the political environment can impact migration patterns (Watkins and Yandle, 2010). In fact, Cebula and Alexander (2006) empirically investigate net interstate migration and extend the migration-investment framework to include positive and negative quality of life characteristics, state and local government policies, and geographic cost-of-living differentials. These economic and non-economic factors in the regional environment can impact local demand and social networks, resulting in deviations in regional venture capital investments.

This paper examines the time series properties of venture capital investments over time and across distinctly different geographical markets. This research can shed light on the dynamic properties of venture capital and how markets may differ over time. Understanding the differences can assist venture capitalists with possible opportunities from a portfolio diversification perspective, while policymakers may be able to identify opportunities to attract venture capital for start-up firms and other en-

trepreneurial activities. This paper provides empirical evidence as to the stationarity properties of venture capital investments across different geographical markets using a battery of panel unit root tests.

3. Data, Methodology, and Results

We use quarterly observations of venture capital investments from the first quarter of 1995 to the fourth quarter of 2012 for a total of 72 observations. The venture capital investment data are from the Price Waterhouse Coopers Money Tree Survey and are reported for the following 18 geographical regions: AK/HI/PR, Colorado, DC/Metroplex, LA/Orange County, Midwest, New England, North Central, Northwest, NY Metro, Philadelphia Metro, Sacramento, San Diego, Silicon Valley, South Central, Southeast, Southwest, Texas, and Upstate NY. All venture capital investment series ($VCI_{i,t}$) have been seasonally adjusted and deflated using the GDP price deflator to convert them to real 2009 dollars. Finally, we calculated the relative shares as follows, $VCI_{i,t}$ = ($VCI_{i,t}$/average VCI shares across all regions$_t$). The

use of relative shares is consistent with the approach used to analyze stochastic convergence in the regional economics literature (e.g., Carlino and Mills, 1993, 1996; List, 1999). Stochastic convergence allows us to examine whether shocks to venture capital investments in a given geographical area (relative to the average venture capital investment across all areas) are temporary. In order to test for stochastic convergence, we utilize a unit root testing framework where rejecting the null hypothesis of a unit root supports stochastic convergence.

Figure 1 plots the relative venture capital investment shares for the different geographical markets. Interestingly, with one exception most markets fluctuate around some long-run mean level that appears relatively stable. That exception is Silicon Valley, with by far the largest relative share, which appears to be stable around some long-run trend. Based on this observation, it appears that the relative shares of each geographical market converge; however, unit root tests are necessary to determine if shocks are temporary or permanent.
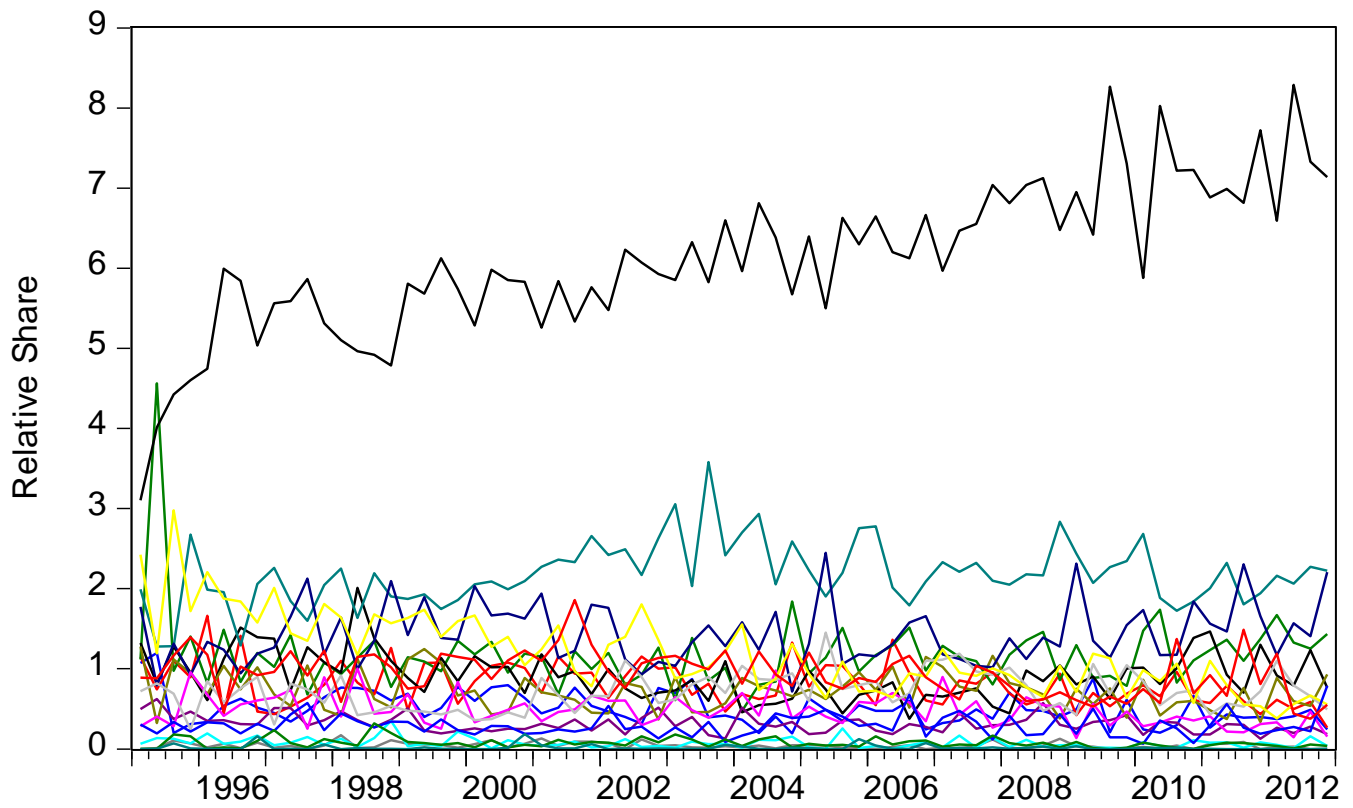

Figure 1. Relative share of venture capital investment by region.

Notes: Data are obtained from the Price Waterhouse Coopers Money Tree Survey. Relative shares (y-axis) are calculated as the amount of venture capital investment for a given region relative to the average venture capital investment across all regions. The relative shares for each of the 18 regions are plotted over the sample period of 1995 to 2012. The highest relative share over much of the sample period is Silicon Valley (denoted by the black line).

In order to examine stationarity (i.e., stochastic convergence), we employed a battery of panel unit root tests with different assumptions about the autoregressive structure. For example, Levin, Lin, and Chu (LLC) (2002) assume homogeneity in the autoregressive coefficients for all panels, while Im, Pesaran, and Shin (IOS) (2003) allow for heterogeneity. Likewise, Maddala and Wu (1999) proposed nonparametric panel unit root tests using the Fisher-ADF and Fisher-PP tests. These tests have the advantage of allowing for as much heterogeneity across units as possible. The LLC, IPS, Fisher-ADF, and Fisher-PP panel unit root tests assume a null hypothesis that the relative share contains a unit root.

Table 1 presents the results of the panel unit root tests, both with and without a trend term. Each unit root test indicates that relative shares across the different geographical markets are integrated of order zero. That is, the relative shares for each market are stationary, providing evidence of stochastic convergence. As such, shocks are only temporary in that the relative shares will adjust back to their respective long-run means. These temporary shocks are consistent with the infusion of venture capital investments in the first round and subsequent convergence (Bertoni, Colombo, and Grilli, 2011) and the migration it may incentivize (Cebula and Alexander, 2006; Foley and Angjellari-Dajci, 2015; Gunderson and Sorenson, 2010; Monchuk and Miranowski, 2010). This finding is also in line with the migration-investment framework (Sjaastad, 1962; Riew, 1973) in that venture capitalists flow from one region to another to maximize their expected return as new ventures become available.

Table 1. Unit Root Tests.

	No trend	Trend	Order of Integration
LLC	-25.29**	-36.92**	I(0)
IPS	-26.04**	-33.02**	I(0)
Fisher-ADF	455.72**	563.92**	I(0)
Fisher-PP	492.29**	565.56**	I(0)

Note: ** (*) denotes significance at the 1 (5) percent level.

4. Implications and Concluding Remarks

The use of panel unit root tests allows us to examine different geographical markets and whether venture capital investments are stochastically converging. If their relative share has a unit root, then the series is unstable and does not revert back to the (long-run) mean following a shock (i.e., divergence). The series examined here were found to be stationary, indicating that the (relative) venture capital investment shares were in fact stable and reverted to their long-run means following any shocks (i.e., convergence). As such, if venture capital investors were to shift their funding from one geographical market to another due to changes in industry configuration or local economic environment, then the relative share for that market would rise compared to the other markets. However, this relative adjustment would only be temporary. This is a finding that various economic models predict, but it is not always supported empirically (Barro and Sala-I-Martin, 1991, 1992; Carlino and Mills, 1993, 1996; Bernard and Durlauf, 1995; Evans and Karras, 1996; Mathur, 1999; Choi, 2004; Higgins et al., 2006; Chen et al., 2010; Mello, 2011).

A finding of stationarity has several implications for venture capitalists, economic developers, and regional policymakers. First, the finding that shocks tend to be temporary in nature indicates that there may be diminishing returns to venture capital investments. As such, regional economic developers may not be competing with one another (in other regional markets) for venture capital but may be competing for other investment alternatives within the same market. For example, more firms within a local area or region may lead to greater competition for venture capital. In fact, Ballinger et al. (2013) find evidence of rivalry among venture capital sectors. Thus, regional economic developers may want to focus on specializing within a particular industry or developing a strong(er) regional cluster that leads to migration of skilled labor (Cebula and Alexander, 2006; Foley and Angjellari-Dajci, 2015). Second, these results suggest that policymakers can use historical data to make resource projections, since the evidence indicates that regional venture capital investment data is stable over time (as shocks are temporary). From a resource perspective, historical data can be used to develop forecasts of venture capital investments to formulate policy decisions in entrepreneurial activities.

Finally, our results also provide evidence of regional convergence with respect to venture capital investments. The finding of stationarity among relative shares is consistent with the literature that finds evidence of convergence in economic activity among regions. Likewise, the policy implications with

regional economic growth consistent with convergence would be applicable to inputs in entrepreneurial growth and start-up activities at the regional level.

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