The Silicon Valley Syndrome

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Abstract

How does expansion in the high-tech sector influence the broader economy of a region? We demonstrate that an infusion of venture capital in a region appears associated with: (i) a decline in entrepreneurship, employment, and average incomes in other industries in the tradable sector; (ii) an increase in entrepreneurship and employment in the non-tradable sector; and (iii) an increase in income inequality in the non-tradable sector. An expansion in the high-tech sector therefore appears to lead to a less diverse tradable sector and to increasing inequality in the region.

1 Introduction

Silicon Valley has been the quintessential high tech cluster. It emerged with the arrival of semiconductors. Orange groves became offices. It then rose to prominence as its startups grew into technology giants first in hardware, then in software, in networking, in on-line businesses, and in social media (Saxenian, 1994; Kenney, 2000; O'Mara, 2019). The modern-day gold rush continues. Today, more of the acclaimed “unicorns” – startups with private valuations in excess of one billion dollars – reside in the Bay Area than in any other part of the country.¹

Yet, Silicon Valley also has its ills. Housing has become scarce and expensive. Few can afford it. Employees have resorted to living out of cars and recreational vehicles and to sharing apartments with dozens of strangers (e.g., Nieves, 2000; Barr, 2019). The tech titans – the likes of Apple, Alphabet, and FaceBook – lavish their employees with pay and perquisites. But other employers struggle with the rising cost of doing business (e.g., Kendall and Castaneda, 2019; Staff, 2019). Entrepreneurs, meanwhile, find it difficult to recruit and retain talent.

The current state of Silicon Valley – especially the growing costs of doing business in the region – reminds us of another phenomenon: the Dutch Disease. The Dutch Disease refers to what happened to the economy of the Netherlands following the discovery of natural gas in the North Sea (Ellman,

¹According to the Bay Area Council Economic Institute, more than half of all unicorn companies in the United States have their headquarters in the Bay Area (Council, 2019).

1981; Corden, 1984). The exporting of large volumes of petroleum led to the rapid appreciation of the Dutch guilder. Currency appreciation, in turn, raised the effective costs for exporters in the manufacturing sector, leading to their demise and the de-industrialization of the Netherlands. This economic boom created a more concentrated and less robust economy.

The Dutch Disease has generally been seen as a national-level phenomenon (Corden and Neary, 1982; Corden, 1984). Since regions do not have their own currencies, they may appear immune to contracting it. But booming industrial clusters can create a similar dynamic.² Rising wages and real estate prices increase the cost of doing business. These rising costs prove particularly problematic for the tradable sector because these businesses must compete with those operating elsewhere, in lower cost places. As a result, the tradable sector of the economy becomes increasingly concentrated on the booming industries.

Studying these dynamics empirically can pose a challenge, particularly in disentangling cause and effect. As a source of semi-exogenous variation, we focus on venture capital. Venture capital has been critical to financing startups and rapidly growing firms in high-tech industries. Changes in its supply therefore create mini-shocks to the tech sector in a region. Indeed, past research has demonstrated that increases in the supply of venture capital stimulates entrepreneurship, creates jobs, and raises regional income (Samila

²Although the booming sectors in the literature have been natural resource-based industries, the formal models of booming and lagging export industries conceptually allow for any type of industry to be the booming sector (e.g., Corden and Neary, 1982).

and Sorenson, 2011). But research has not considered the extent to which these effect may vary across industries, creating winners and losers.

We treat the industry-region-quarter as the unit of analysis. Within these units, our analyses estimate the relationship between an increase in venture capital funding over a five-year period and entrepreneurship, employment, and average income in the subsequent quarter. We divide industries into three groups: (1) the portion of the tradable sector of interest to venture capitalists; (2) the remainder of the tradable sector; and (3) the non-tradable sector. We explore the differential effects of venture capital across these three groups of industries over a window running from 2003 to 2012.

Infusions of venture capital appear associated with three patterns. The tradable sector as a whole contracts; the number of firms and employees drop and average income actually falls within these industries, with rising venture capital. By contrast, the number of firms and employees in the non-tradable sector increases. Income within the non-tradable sector, meanwhile, becomes more dispersed. While those at the bottom of the income distribution – such as bartenders and waiters – experience no changes in their earnings – those as the top – such as dentists and doctors – earn more.

Overall then, inequality almost certainly rises with infusions of venture capital. The tradable sector generally accounts for the wealth of a region and provides its better-paying jobs (Verhoogen, 2008; Helpman et al., 2010). As this segment of the economy declines, it hollows out the middle of the income distribution. The non-tradable sector, meanwhile, becomes more unequal in

response to venture capital investments. The poor do no better while the rich get richer. This combination of the crowding out of the other segments of the tradable sector with rising income inequality appears to be the signature symptoms of the Silicon Valley Syndrome.

2 The Dutch Disease

In the 1960s, the Netherlands began to export natural gas and related products in large and growing quantities.³ The value of the Dutch guilder rose relative to other currencies. Other exporting industries therefore experienced corresponding increases in their costs of production (in terms of the currencies of importing countries). In fact, declines in manufacturing exports ended up being so severe that they more than offset the exports of petroleum. Exports as a whole fell.

The “Dutch Disease” has therefore become a popular term for the idea that a booming extraction sector – whether oil, natural gas, or diamonds – can crowd out a lagging manufacturing sector.⁴ Three main mechanisms produce the symptoms. First and foremost, the rapid rise in exports of the natural resource leads to an appreciation in the currency (Gylfason et al., 1999). Because manufacturers cannot easily reduce their wages and other

³For extended reviews of the history behind the Dutch Disease, see Ellman (1981) and Corden (1984).

⁴*The Economist* actually coined the term in 1977 (Corden, 1984). Note that the Dutch Disease differs somewhat from the “resource curse” literature (e.g., Mehlum et al., 2006; Komarek, 2018). The resource curse has often been associated with crime, corruption, and a failure to build strong institutions in the literature on economic development.

expenses, they experience an increase in their costs relative to competing producers in other countries. Exporters outside the booming sector therefore find it difficult to compete.

Second, the booming natural resource sector offers higher returns. Firms in the extraction sector can afford to pay higher salaries to employees. They also offer higher interest rates and more attractive returns to investors. Talent and capital therefore flow out of other industries into the booming sector (Corden and Neary, 1982). Not only do other parts of the tradable economy experience higher costs but also they may find themselves starved of human and financial capital.

Third, the dependence of exports on natural resource prices leads to increasing instability in exchange rates. The prices of commodities often swing wildly as supply and demand move temporarily out of equilibrium. When commodities account for a large share of exports, these fluctuations propagate into exchange rates. Exchange rate volatility increases the uncertainty investors face and therefore further depresses capital investment, both in the tradable and non-tradable sectors (Gylfason et al., 1999). These fluctuations also complicate the management of global supply chains.

3 The Silicon Valley Syndrome

At first blush, the Dutch Disease feels far removed from Silicon Valley. Leaving aside any legacy of the gold rushes of the 1800s, Silicon Valley's

wealth comes from entrepreneurship and innovation not from the extraction of natural resources. As a region in a large state in an even larger country, moreover, Silicon Valley would seem immune to the exchange rate issues underlying the Dutch Disease.

But adjustments can occur on many margins. The booming tech sector in Silicon Valley has almost certainly increased the price of doing business there. To recruit and retain talent, the high-tech titans have raised pay and perquisites to new levels—in addition to high salaries, employment at the leading high-tech firms often includes access to free gyms and cafeterias and even to exclusive buses to and from the company campuses (e.g., Schrodtt, 2017). Real estate costs have also been rising rapidly.

Far from being unique to Silicon Valley, these rising costs probably represent a general feature of a booming technology sector. Consider the design side of Apple, the Google search engine, or Abbvie's Humira antibody. Because few alternatives exist, these products and services generate enormous, windfall-like, profits for the firms producing them. Firms in these booming technology industries can therefore afford to pay high salaries and high rents, and they offer investors attractive returns (Corden and Neary, 1982).

Real estate prices soar as these firms and their well-paid employees compete for the limited supplies of office space and of housing. Booming high-tech industries, moreover, may have unusually large effects on residential real estate prices in a region.⁵ Because equity awards factor so heavily into

⁵These real estates run-ups have undoubtedly been more severe in Silicon Valley because

compensation in these industries, employees themselves experience windfalls in wealth when their firms get acquired or go public. Employees often use these windfalls to purchase housing.

Whether other factor prices rise in real terms at a regional level, however, depends in part on the mobility of labor and capital. At the national level, borders create barriers. Whether due to language differences or legal restrictions on entry, employees from outside the country often find it difficult to immigrate in response to rising wages. Exchange rates similarly deter the movement of financial capital into a country. In the context of the Dutch Disease then, thinking of the factor side of the economy as being relatively fixed does not represent a heroic assumption.

Regions actually do not seem so different. Although regions within countries experience some expansion in the supply of capital and talent in response to a booming tradable sector, people and money do not flow freely across places. Employees, for example, appear strongly attached to the regions in which they have family and friends (Dahl and Sorenson, 2010). They only move when they can expect to earn tens of thousands of dollars more in another place. As a consequence, even large differentials in real wages across regions can persist for extended periods of time.

Capital similarly exhibits a strong home bias. Lenders and equity investors favor firms near them when they choose where to invest (Coval and

it has one of the most constrained housing supplies in the world. Natural features of the area, such as the fact that it sits on a geologically-unstable peninsula, impose some constraints. But tax policy, zoning, and building restrictions exacerbate this situation.

Moskowitz, 1999; Sorenson and Stuart, 2001; Petersen and Rajan, 2002). Whether this tendency reflects the fact that investors have better information on firms headquartered near them (van Nieuwerburgh and Veldkamp, 2009) or the possibility that investors may have biased opinions in favor of familiar firms (Sorenson and Waguespack, 2006) remains an open question. Regardless of the reason, however, even within countries, financial capital ends up disproportionately deployed near its owners.

3.1 Tradable vs. non-tradable industries

The consequences of these rising factor prices vary by sector of the regional economy. A booming tech sector should crowd out the production of other tradable goods and services in the region. The tech sector pulls employees and capital away from these businesses. It also raises their effective costs of production. But businesses in the tradable sector, almost by definition, must compete with those located elsewhere, in regions not experiencing a tech boom and therefore not subject to such cost inflation. These businesses therefore become increasingly uncompetitive at the national and international levels.

But the non-tradable sector by comparison might actually grow in response to these dynamics. Although the non-tradable sector must also contend with rising costs, businesses in these industries need not compete with those elsewhere with lower cost structures.

The expansion of the tech sector also has a spending effect.⁶ As employment in the tech sector expands and as these employees earn more, their demand for many types of local services, from coffee shops to orchestras, increases. Consistent with this expectation, several studies have found positive associations between employment in the tradable sector and employment in the non-tradable sector (Moretti and Thulin, 2013; van Dijk, 2017; Brenner et al., 2018).

Interestingly, the demand for certain types of non-tradable services might rise more than others in response to a high-tech boom. High-end offerings, such as live music and sporting events and Michelin-starred restaurants, cannot easily expand their capacity. They therefore become status goods, sought after by those at the top of the income distribution (Veblen, 1899). Given the high salaries in and the wealth created by the tech sector, rising demand for these luxury goods likely outstrips any increase in their supply.

4 Empirical Strategy

Investigating these processes can prove difficult. Most notably, the direction of causality might flow in either direction. The demise of the manufacturing sector in a region might release resources—freeing managerial and employee talent for use elsewhere in the economy (Sorenson, 2017). The technology cluster in Waterloo, Ontario, for example, arose from the ashes

⁶Models of the Dutch Disease also predict a spending effect in the non-tradable sector (e.g., Corden and Neary, 1982).

of Research in Motion (the company that made the Blackberry).

A common strategy for dealing with this type of endogeneity has been to find some sort of shock to the local economy that can serve as a source of econometric identification. In examining the effects of natural resources on local economies, researchers have, for example, examined the discovery of oil and natural gas deposits in the region (Decker et al., 2017). In regions already producing commodities, such as agricultural products, they have used fluctuations in the international prices for these commodities as a source of exogenous variation (Allcott and Keniston, 2018; Bernstein et al., 2018).

We believe that the supply of venture capital in a region provides a similar source of pseudo-exogenous variation for high tech industries. Venture capital firms, financial intermediaries that provide funding to private companies in return for equity, have been on the rise in the United States since the 1980s. The National Venture Capital Association (NVCA) reports that, in 2017, venture capital firms in the United States deployed more than \$80 billion into new investments and held more than \$350 billion in assets under management.

Two features of venture capital prove useful for our purposes. First, venture capital firms invest locally. Much has been written about the “one hour” rule, by which venture capitalists will not invest in companies outside of a one hour travel-time radius from their offices. Two forces appear responsible for this effect. When evaluating potential investments, venture capitalists rely on their social relationships for due diligence (Sorenson and Stuart, 2001).

Since these relationships connect them primarily to the regions in which they live and work, they have limited ability to consider deals elsewhere. Venture capitalists also prefer to invest locally so that they can monitor and advise the companies in which they invest (Bernstein et al., 2016).

Second, venture capital stimulates the growth of the firms in which it invests and the economic growth of the regions where those firms reside. At the firm level, for example, firms backed by venture capital operate more professionally and more efficiently, and grow more rapidly (Hellmann and Puri, 2002; Davila et al., 2003; Bertoni et al., 2011; Chemmanaur et al., 2011). At the regional level, venture capital encourages entrepreneurship, creates jobs, and raises regional income (Samila and Sorenson, 2011).

One might nonetheless worry about the potential endogeneity of venture capital investments themselves. If venture capitalists scan the country for attractive opportunities, their decisions to invest in particular regions might stem from them foreseeing high future returns in those places, perhaps due to the discovery of an important technology. Any apparent regional effects, therefore, might stem from these underlying trends rather than from the venture capital investments themselves.

But two lines of research suggest that such active searching should not pose an endogeneity problem at the regional level. On the one hand, venture capital firms do not appear to have any unusual insight into which firms will succeed (Mollick, 2013; Nanda et al., 2019). Even venture capitalists with a history of successful investments do no better than chance in terms of their

ability to choose the next hot technology or the next emerging region (Nanda et al., 2019).

On the other hand, research that has examined the effects of venture capital at the regional level has found little evidence of endogeneity. Notably, analyses using instrumental variables to eliminate the influence of endogeneity in the supply of venture capital yield equivalent results, in terms of direction and magnitude, to those from naïve panel estimation (Samila and Sorenson, 2011).

5 The Data

Our data on entrepreneurship, employment, and average wages come from the Quarterly Census of Employment and Wages (QCEW) dataset of the Bureau of Labor Statistics (BLS). This database covers more than 95% of all jobs in the United States. Our measures of venture capital activity, meanwhile, have been derived from the Thomson Reuters’ VentureXpert database.⁷ We use population data from the Census Bureau.

We constructed a panel dataset covering all Metropolitan Statistical Areas (MSAs) in the United States from 2003 to 2012. The U.S. Office of Management and Budget (OMB) defines an MSA by selecting a core urban

⁷Because the United States does not require venture capital firms to register or to report their activities, a comprehensive list of all venture capital investments does not exist. VentureXpert nevertheless appears to offer the most complete database on these investments and has been the one most commonly used by academics studying the industry (Kaplan and Lerner, 2017; Nanda et al., 2019).

area with at least 50,000 inhabitants and joining it with surrounding counties where at least 25% of the residents commute to that urban area. They therefore represent reasonably independent economic units.

We chose our time window to ensure stability in these areal units. The OMB redefines MSAs in response to each census. For example, the current set of MSAs stem from the 2010 census. These redefinitions typically occur three years after the census. Our 2003 to 2012 period therefore captures a consistent set of regions based on the 2000 census.

Although the government currently identifies more than 380 MSAs in the United States, several of these units only appeared with the incorporation of information from the 2010 census. In 2003, the OMB had defined 369 regions as MSAs. Eight of them were in Puerto Rico, which we exclude from our analysis. The BLS, moreover, did not have QCEW data available for two MSAs: Danville (VA) and Sandusky (OH). Our final dataset therefore contains a total of 359 MSAs.

The BLS reports information on employment and business activity within six-digit North American Industry Classification System (NAICS) codes. Examples of industries at this level of disaggregation would include “plastics bag and pouch manufacturing” (NAICS 326111), “motor home manufacturing” (NAICS 336213), and “full-service restaurants” (NAICS 722511). The BLS reports this information each quarter. The MSA-industry-quarter therefore serves as our unit of observation.

5.1 Dependent variables

Exactly how activity in the high-tech sector might influence the economy depends on how entrepreneurs and organizations adjust to the rising demand from the sector. Potential entrepreneurs, for example, might recognize the challenges or opportunities, either entering or forgoing entry based on their perceptions of the environment. But existing businesses might also expand or contract. We therefore consider multiple measures of business activity in each industry.

The BLS does not report information on the numbers of business starts or closings. But they do provide information on the number of establishments – defined as a single physical location where business occurs – in each industry and region. We therefore use the logged number of establishments as our first outcome of interest.⁸ Increases and decreases in the number of establishments, however, stem both from the births and deaths of entire enterprises and from openings and closings of locations (e.g., a chain restaurant opening or closing an outlet).

Employment simply counts the total number of jobs in a region at establishments in a particular industry. It includes both full-time and part-time employees. Note that this count can potentially include an individual more than once if the person has more than one job. We log this count as our measure of employment.

⁸For privacy reasons, the BLS does not disclose industry-region information that would aggregate fewer than three firms. Although this requirement means that some industry-regions drop out of our analysis, it also ensures that we only have positive observed counts.

We use average weekly income per job, for a particular industry and region, as a measure of the earnings associated with those jobs. Although we refer to this measure as wages, it includes a variety of types of income. Bonuses, stock options, reported tips, and retirement benefits, for example, would all appear in these totals. For part-time employees, increases in these average earnings could stem either from changes in the number of hours worked or in the average amount earned per hour.⁹ Once again, we log these average wages when using them as a dependent variable.

5.2 Venture capital

We considered three different measures of the supply of venture capital: the number of first-round investments, the total number of investment rounds, and the total amount invested by venture capital firms in startups headquartered in an MSA.¹⁰ We sum these measures over five years and log them (adding one dollar to the summed amount to avoid missing values in regions that did not receive any venture capital investments for a five-year period). Table 1 lists the top-15 industries in terms of amount of venture capital received since 1985.

These three measures essentially weight different stages of venture capi-

⁹The BLS data do not report hours worked on a quarterly basis so we cannot adjust for this margin in our analysis.

¹⁰VentureXpert reports two investment amounts: the disclosed amount and the estimated amount. Although the estimated amount has fewer missing values, the disclosed amount provides more accurate information. Our models therefore report estimates using sums of the disclosed amounts.

tal investment. First round investments, roughly a measure of the number of venture-capital-backed startups in the region, capture the effects of the earliest round of funding. The number of investment rounds equally weights earlier- and later-stage investments. Meanwhile, the total amount invested effectively weights later-stage investments most heavily since the size of these investments dwarfs earlier rounds. Later-stage rounds in unicorns have often brought in billions of dollars whereas a typical first-round investment might amount to no more than one million dollars.

Prior research suggests that early-stage investments have stronger effects on the local economy than later ones (Samila and Sorenson, 2011). As companies mature and expand, they deploy more and more of the capital that they raise outside of the regions that they call home. Relatively little of the billions of dollars invested in Uber over the past few years, for example, has gone to hiring people in the Bay Area. Most of it has been dispersed around the globe to subsidize drivers in the dozens of cities in which it operates.

Our measures of venture capital activity aggregate the number of investments and the amount of funds invested for the five years prior to each quarter. We do so for two reasons. First, because of the small numbers of companies being funded, these measures bounce around from one quarter to the next. Smoothing helps to reduce underestimation due to the noisiness of the measure (i.e. attenuation bias). Second, the effects of venture capital investments unfold over time. Samila and Sorenson (2011), for example, reported that venture capital had significant effects on regional economic

growth for at least three years following the year of an investment. By aggregating across five years, our estimates capture these regional economic effects for five years from the time of investment.

5.3 Tradable vs. non-tradable

The empirical literature on the Dutch Disease has typically equated the tradable sector with manufacturing (Allcott and Keniston, 2018). That assumption would not have been so problematic at the time that the Netherlands discovered oil, as manufacturing did then account for the vast majority of exports. But in modern economies, services can also account for a large share of what gets produced in a region but consumed elsewhere.

As part of their effort to understand industrial clusters, Delgado et al. (2014) have created a classification of industries in terms of being traded or not. Their definition incorporates cutoffs on multiple criteria, such as the proportion of regions with no employment in the industry and the degree of geographic concentration of employment. We use this classification for our primary analysis. We, however, modify it to exclude traded industries that themselves have received a large amount of venture capital.¹¹

But their coding also has a disadvantage for our purposes: It defines industries as being either traded or non-traded (local). Many industries, however, especially services, probably reside someplace in between. They

¹¹We classify industries as having received a large amount of venture capital if more than 1% of venture capital dollars during our window went to the industry.

vary in the degree that they serve customers elsewhere. We might therefore prefer a measure of the degree of being traded.

To address this issue, we created our own measure of industry “tradability” —the extent to which businesses in an industry probably sell their goods and services outside of the region in which they produce them. We assess tradability by using the geographic Theil Index (TI):

$$TI_j = \frac{1}{N} \sum_{i=1}^N p_{ij} \log\left(\frac{1}{p_{ij}}\right), \quad (1)$$

where i indexes regions and p equals the proportion of all jobs in industry j located in region i . In essence, our measure captures the extent to which employment in an industry spreads evenly across regions in the United States. The higher the Theil Index, as calculated by (1), the more local the industry. Because regions must produce their own non-traded goods and services, employment in these industries should end up distributed fairly evenly across regions. Concentration in production primarily occurs when one region can export to another. Table 2 provides descriptive statistics for the variables of interest.

6 Results

We estimate the effects of the supply of venture capital on the number of establishments, the number of jobs, and average weekly wages for each

industry in each region. We allow these effects to vary according to the characteristics of the industry, namely whether we consider it part of the traded sector or not. Our models include MSA-level fixed effects to control for time-invariant characteristics of regions that may influence both the economic vitality of the region and the amount of venture capital invested there. We also include quarter fixed effects to account for any national-level trends in economic activity. We also control for the (logged) population in the region.

Our log-on-log specifications allow one to interpret the coefficients as elasticities. These elasticities may seem small but venture capital funds a thin slice of the economy even in the most heavily-concentrated high-technology clusters. Even small elasticities therefore often imply out-sized effects of these investments on the regional economy (Samila and Sorenson, 2011).

6.1 Discrete sectors

Table 3 reports the results for the effects on the number of establishments. Consider first the left-most column. In these models, the control variables for the traded and non-traded sectors capture differences in the average number of establishments within these industries. Non-traded businesses tend to have more locations than traded ones. That’s not surprising. Many local businesses – such as restaurants or gas stations – have small catchment areas and therefore require many outlets to serve geographically-dispersed consumers. Population, meanwhile, captures the extent to which

the number of establishments expands with population growth.¹²

The results of interest concern the effects of venture capital. We have estimated these models using “effects” coding. In other words, the main effect of venture capital captures the average effect of venture capital across all industries in the economy. The interaction effects – for traded and non-traded industries – then estimate the extent to which the effects in those sets of industries deviate from the average effect. In this first model, the total amount of venture capital dollars has a small, positive effect on the number of establishments in the economy. But the effects vary across sectors. Whereas the number of establishments increases in the non-traded sector with an increase in the amount of venture capital invested in the region, it decreases in the traded sector (outside of those industries receiving venture capital investments).

The next two columns estimate the same models but with alternative measures of venture capital activity, number of venture capital investment rounds (second column) and number of first-round investments (third column). We see the same pattern: Venture capital investments lead to more establishments in the non-traded sector but to fewer in the traded sector. Earlier-stage investments, however, have larger effects on the number of establishments than later-stage investments. For example, whereas a 1% in-

¹²To the extent that population growth stems from people moving into the region in response to the favorable economic conditions there, one could argue that the models should not adjust for population size (because it becomes endogenous to economic growth). Excluding this variable yields somewhat larger effect sizes.

crease in the amount of venture capital predicts a 0.027% increase in the number of establishments in the non-traded sector, a 1% increase in the number of venture capital rounds and first rounds predict 0.085% and 0.11% increases, respectively, in this number of establishments.

Table 4 describes a parallel set of models for the number of jobs. Once again, venture capital has a positive effect, on average, on employment in the region. Interestingly, the size of the effects estimated here correspond closely to those found by Samila and Sorenson (2011), for the effects of venture capital on employment for 1993–2002. Our estimates suggest somewhat larger elasticities in our more recent period but our measure captures jobs rather than full-time equivalent jobs, as in Samila and Sorenson (2011). The differences therefore could stem either from venture capital having larger effects on employment in the more recent period or from venture capital being associated with the creation of more part-time jobs.

But these average effects mask massive variation in the employment effects across industries. Whereas infusions of venture capital predict large increases in employment in the non-traded sector, these gains end up being offset by declines in employment in the traded sector. Once again, earlier-stage investments predict larger effects than later-stage investments, consistent with companies deploying much of this later-stage funding outside of the regions where they are headquartered.

Table 5 finally reports models for average weekly wages. Venture capital has no average effect on weekly wages. That might seem surprising given that

Samila and Sorenson (2011) found that venture capital increased regional income. But, rather than average income, they studied aggregate income—the average income *times* the number of jobs. If we used aggregate income, we too would find a positive effect, but it would stem not from increases in average income but from growth in the number of jobs.

Although income does not rise on average, infusions of venture capital do raise income for those in the non-traded sector. By contrast, venture capital investments predict declining income in the traded sector. This latter effect seems surprising. But recall that the traded sector in these models does not include industries funded by venture capital. This coefficient therefore represents a relative difference: Traded industries that do not receive venture capital funding have slower wage growth than those that do. But this effect probably also stems, in part, from changes in the composition of employees. As the high-tech sector recruits those with the highest human capital away from other parts of the traded sector, those remaining in these industries will have lower average earnings.

6.2 Continuous tradability

As noted above, rather than being traded or non-traded, industries vary along a continuum in the extent to which they serve customers at a distance. Consider accounting. Larger firms in this industry often serve customers at a regional, national or even global scale. But smaller accounting firms typically have clients only within their cities. By contrast, gas stations operate only

at a local level. We therefore also analyzed the data using our continuous measure of tradability.

Table 6 reports the results of these models. Although this table only details the results using the total amount of venture capital, our other measures of venture capital also produce equivalent effects with the continuous measure as they did with the discrete one. Across all of the outcomes, the effects for the continuous measure parallel those using the discrete sectors. Using either measure of being tradable, moreover, earlier-stage investments have larger effects on the regional economy than later-stage ones.

Recall that a value of zero on our continuous measure would imply that the entire industry resided within a single MSA. The “main” effects of venture capital in these models therefore capture the effects of venture capital in a highly concentrated industry, one that produces in one location but sells to consumers across the country. In these tradable industries, increases in the amount of venture capital invested in a region predict reductions in the number of establishments and the number of jobs, and in the average earnings of these employees. But as industries become more dispersed, the effects shift. For industries that are dispersed across regions (non-tradable industries), infusions of venture capital led to increases in the number of establishments and the number of jobs, as well as to rising wages.

6.3 Heterogeneity in the non-traded sector

We finally explored whether local (non-traded) industries varied in their response to venture capital investments in the region. As noted above, services that require highly-skilled employees may have greater difficulty expanding their operations. To explore this issue, we split the non-traded sector into four groups, based on their average weekly wage at the national level. The bottom group, for example, includes retail bakeries, grocers, and convenience stores. The top group, meanwhile, includes clinics and hospitals, commercial banks, and law firms.

Table 7 reports the results of regressions where we allow infusions of venture capital to have different effects across these subsets of non-traded industries. The first column reports results for the number of establishment, the second column the number of employees, and the third column average weekly wages. Venture capital has consistent and similar effects on the number of establishments and the number of jobs across these groups. But average weekly wages diverge. In the lowest income quartile, average income actually declines. But as one moves up the income quartiles, the effects of venture capital on average income becomes more and more positive. Income inequality rises.

7 Discussion

Policymakers around the globe have seen Silicon Valley as a model for economic development. In some ways, they should envy it. The high-tech cluster there has propelled the region to having the highest per capita income of any region in the United States. But Silicon Valley also has a dark side: Housing has become unaffordable to most; the cost of doing business there has risen rapidly; and the dynamism of the economy has been declining (Fairlie and Chatterji, 2013).

We cast these regional economic dynamics as a cousin of the Dutch Disease. In many countries, the discovery of natural resources has led to economic booms based on extracting and exporting these resources. But these booms simultaneously render these national economies fragile, as the natural resource sector crowds out other exporters. Although an expanding high-tech sector may stimulate the demand for local goods and services, it can crowd out other tradable industries within the region, as it consumes human and financial capital.

We explore these dynamics empirically by estimating the effects of infusions of venture capital on regional economies, metropolitan standard areas in the United States. These investments create small, semi-exogenous jolts to the local tech sector, allowing us to explore how the expansions they fund ripple through the economy.

Investments of venture capital have different effects for businesses in the

traded and non-traded segments of the economy. In the traded sector, these infusions of capital predict future declines in the number of establishments, in aggregate employment, and in average earnings. The high-tech sector therefore appears to crowd out other exporting industries.

Meanwhile, the non-traded sector expands. Infusions of venture capital increase the number of establishments in these industries, the aggregate number of jobs available in them, and the average earnings of those holding these jobs. Wealth created by the tech sector leads to a spending effect, increasing the demand for local goods and services.

But venture capital does not have uniform effects on businesses in this sector. Although the effects on firm and job creation appear fairly constant across the sector, the effects of venture capital on income vary across the types of businesses. Lower-wage businesses – those that employ less-skilled and less-specialized employees – actually pay their employees a little less following infusions of venture capital. But employees in higher-wage businesses experience earnings growth. Income equality therefore rises within the non-traded sector.

We contribute to at least two streams of literature. Although prior research has demonstrated that venture capital stimulates the growth of regional economies (Samila and Sorenson, 2011), it has not examined the extent to which this growth stems directly from the businesses being funded versus indirectly through multiplier effects, as the wealth from these rapidly-growing enterprises spills out into the regional economy. Our results suggest

that most of the increase in entrepreneurship and employment stems not from venture capital increasing the number of high-tech businesses but rather from it expanding the non-traded sector. This spending effect parallels that found in response to income shocks in other exporting sectors, such as agriculture (Bernstein et al., 2018) and extraction (Allcott and Keniston, 2018).

Our study also contributes to the literature on the crowding out effects of booming industries in two ways. First and foremost, our results suggest that crowding out represents a common phenomenon rather than one limited to a rapid rise in the natural resource sector. Second, whereas the prior literature has generally treated such crowding out as a national-level phenomenon, we add to the small number of recent studies showing that these processes operate even across regions within countries (Beine et al., 2015; Cust and Poelhekke, 2015).

The implications for regional development seem at least two-fold. On the one hand, the dynamics unfolding here point to another self-reinforcing dynamic in the emergence and persistence of industrial clusters. A substantial stream of research has shown that the geographic concentration of industries limits where entrepreneurs in the industry can found their firms (Sorenson and Audia, 2000; Klepper, 2010; Sorenson, 2017). But regional economies may also become increasingly concentrated on a small set of industries as the highly-productive firms in these clusters crowd out other employers in the tradable sector, further limiting the supply of future entrepreneurs in other industries.

On the other hand, our results also point to an unintended downside to regional concentrations of high-tech industries: increasing economic inequality. These industries create wealth. But the “trickle down” effect of this wealth, as the owners and employees of these companies increase their spending on local goods and services, only appears to go so far down. It benefits those at the high end—the already well-off accountants, doctors, and lawyers. But those at the lower end of the service economy, the servers and taxi drivers, appear simply to fall further behind.

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Table 1: Venture Capital Investments by Industry

Software production	207
Internet service providers	83
Semiconductor manufacturing	74
Pharmaceutical manufacturing	45
R&D in the engineering and the sciences	34
Biological product manufacturing	27
Small arms manufacturing	23
Data processing and services	22
Commodity contracts dealing	22
Taxi service	21
Telecommunications carriers	19
Computer systems design	18
Electromedical manufacturing	17
Custom computer programming	15
Communications equipment manufacturing	13

*In billion dollars, 1985 - 2017

Table 2: Descriptive Statistics

Variables	Mean	SD	Min	Median	Max
Non-traded sector*					
Number of industries	182	18	107	186	207
Establishments	4,346	10,530	52	1,335	116,728
Employment (jobs)	49,845	121,610	944	14,378	1,2791,001
Average weekly wage (\$)	367	71	250	357	733
Traded sector*					
Number of industries	262	104	74	228	588
Establishments	3,314	12,350	23	683	189,560
Employment (jobs)	32,803	99,711	155	6,243	1,097,959
Average weekly wage (\$)	691	205	265	660	1,880
VC investment (per year)**					
Amount (\$1000s)	313,243	1,895,558	0.0	1,290	25,422,158
Number of rounds	29	165	0.0	0.4	2,157
Number of first rounds	6	33	0.0	0.2	493
Theil Index*	2.1	0.9	0.0	2.4	3.8

* Across all regions, 1st Quarter, 2003

** Across all regions, 2003–2012

Table 3: Entrepreneurship

	<i>Dependent variable:</i>		
	Establishments		
	(1)	(2)	(3)
Population	0.097** (0.043)	0.097** (0.043)	0.093** (0.043)
Non-traded	0.168*** (0.009)	0.172*** (0.008)	0.192*** (0.008)
Traded	-0.266*** (0.009)	-0.269*** (0.008)	-0.287*** (0.008)
VC amount	0.002*** (0.001)		
VC rounds		0.006 (0.004)	
VC first rounds			0.003 (0.005)
VC amount × non-traded	0.027*** (0.002)		
VC amount × traded	-0.024*** (0.002)		
VC rounds × non-traded		0.085*** (0.004)	
VC rounds × traded		-0.076*** (0.004)	
VC first rounds × non-traded			0.110*** (0.006)
VC first rounds × traded			-0.098*** (0.005)
Region FE	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
Quarter FE	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
Adj. R ²	0.295	0.298	0.299
Observations	9,183,852	9,183,852	9,183,852

Note: *p<0.1; **p<0.05; ***p<0.01

Table 4: Employment

	<i>Dependent variable:</i>		
	Jobs		
	(1)	(2)	(3)
Population	0.106** (0.046)	0.105** (0.046)	0.102** (0.045)
Non-traded	0.308*** (0.016)	0.320*** (0.016)	0.345*** (0.016)
Traded	-0.489*** (0.016)	-0.494*** (0.016)	-0.517*** (0.016)
VC amount	0.002*** (0.001)		
VC rounds		0.009** (0.003)	
VC first rounds			0.011*** (0.004)
VC amount × non-traded	0.029*** (0.002)		
VC amount × traded	-0.028*** (0.002)		
VC rounds × non-traded		0.090*** (0.007)	
VC rounds × traded		-0.087*** (0.007)	
VC first rounds × non-traded			0.113*** (0.010)
VC first rounds × traded			-0.110*** (0.010)
Region FE	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
Quarter FE	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
Adj. R ²	0.161	0.162	0.161
Observations	9,183,852	9,183,852	9,183,852

Note: *p<0.1; **p<0.05; ***p<0.01

Table 5: Income

	<i>Dependent variable:</i>		
	Average weekly wages		
	(1)	(2)	(3)
Population (Log)	0.091 (0.059)	0.090 (0.059)	0.088 (0.059)
Non-traded	0.472*** (0.018)	0.492*** (0.018)	0.514*** (0.018)
Traded	-0.634*** (0.017)	-0.641*** (0.016)	-0.654*** (0.016)
VC amount	0.001 (0.001)		
VC rounds		0.004 (0.005)	
VC first rounds			0.002 (0.005)
VC amount × non-traded	0.019*** (0.002)		
VC amount × traded	-0.012*** (0.002)		
VC rounds × non-traded		0.052*** (0.007)	
VC rounds × traded		-0.035*** (0.006)	
VC first rounds × non-traded			0.060*** (0.010)
VC first rounds × traded			-0.041*** (0.008)
Region FE	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
Quarter FE	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
Adj. R ²	0.107	0.107	0.107
Observations	9,183,852	9,183,852	9,183,852

Note: *p<0.1; **p<0.05; ***p<0.01

Table 6: Theil Index

	<i>Dependent variable:</i>		
	Establishments	Jobs	Weekly wages
	(1)	(2)	(3)
Population	0.117*** (0.044)	0.148*** (0.051)	0.162** (0.064)
Theil Index	0.509*** (0.014)	0.848*** (0.029)	1.229*** (0.032)
VC amount	-0.088*** (0.004)	-0.100*** (0.008)	-0.043*** (0.008)
VC amount × Theil Index	0.040*** (0.002)	0.045*** (0.004)	0.020*** (0.004)
Region FE	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
Quarter FE	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
Adj. R ²	0.571	0.318	0.243
Observations	6,164,543	6,164,543	6,164,543

Note: *p<0.1; **p<0.05; ***p<0.01

Table 7: Variation in the non-traded sector

	<i>Dependent variable:</i>		
	Establishments	Jobs	Weekly wages
	(1)	(2)	(3)
Population	0.099** (0.043)	0.108** (0.045)	0.091 (0.059)
Traded	−0.345*** (0.013)	−0.638*** (0.024)	−0.866*** (0.025)
VC amount	0.016*** (0.001)	0.017*** (0.002)	0.011*** (0.002)
VC amount × traded	−0.038*** (0.002)	−0.043*** (0.004)	−0.022*** (0.003)
Non-traded			
Low wage	0.379*** (0.009)	0.625*** (0.021)	0.417*** (0.020)
Mid-low wage	0.127*** (0.007)	0.256*** (0.017)	0.424*** (0.022)
Mid-high wage	0.007 (0.005)	−0.028** (0.013)	0.200*** (0.021)
High wage	−0.185*** (0.006)	−0.247*** (0.017)	−0.105*** (0.025)
VC amount × non-traded			
Low wage	0.018*** (0.001)	0.010*** (0.003)	−0.014*** (0.003)
Mid-low wage	0.016*** (0.001)	0.014*** (0.002)	0.004* (0.002)
Mid-high wage	0.008*** (0.001)	0.012*** (0.002)	0.014*** (0.002)
High wage	0.012*** (0.001)	0.024*** (0.003)	0.034*** (0.003)
Region FE	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
Quarter FE	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
Adj. R ²	0.303	0.164	0.108
Observations	9,183,852	9,183,852	9,183,852

Note: *p<0.1; **p<0.05; ***p<0.01