Entrepreneurship, Mines, and Urban Growth

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Abstract

There is a well established correlation between initial entrepreneurship and subsequent employment growth across metropolitan areas. This relationship is true when modelling entrepreneurship through average establishment size or through the prevalence of start-ups; the relationship also holds at the industry level within cities. These patterns are often taken as evidence that entrepreneurship promotes city success.

Spatial differences in initial entrepreneurship are unlikely to be exogenous, however, which bedevils interpretation. Chinitz (1961) hypothesized that industrial legacies explain why some cities are less entrepreneurial than others. He particularly keyed in on industries like steel in Pittsburgh that are very dependent upon natural resources and possess large firms that depress entrepreneurship. We follow this idea by looking at the spatial location of mines across the U.S. at the start of the 20th century.

We find that greater historical mining deposits are strongly correlated with reduced entrepreneurship in the middle of the 20th century. The link between entrepreneurship and local employment growth persists when instrumenting initial entrepreneurship with historical mines. These effects are evident in industrial clusters that are not directly related to mining, such as trade, finance and services. They are also present in cities with warm climates, suggesting that these results do not simply reflect the Rust Belt's decline.

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1 Introduction

Economists and policy makers often argue that urban success depends upon a city's level of entrepreneurship. This claim was famously made in Chinitz's (1961) comparison of New York and Pittsburgh, and it is more recently invoked by Saxenian (1994) when contrasting the regional performance of Boston and Silicon Valley. More systematic empirical evidence confirms these famous case studies. For example, Glaeser et al. (1992) find a strong correlation between small establishment size and subsequent employment growth across sectors within U.S. cities. Glaeser, Kerr and Ponzetto (2010) also document the strength of this relationship when modelling entrepreneurship through start-up employment shares. Similar conclusions are reached recently by Delgado, Porter and Stern (2010a,b) and Rosenthal and Strange (2003, 2010).[1]

Figures 1a and 1b provide representative graphs from this work. These patterns are frequently taken as evidence that entrepreneurship is an important ingredient for local job growth. While the empirical association is quite visible, there are clearly many factors that jointly influence initial entrepreneurship levels and subsequent growth of cities (e.g., regional growth trends, local public policies). Without identifying exogenous sources of variation for entrepreneurship, it is pre-mature to make strong claims that entrepreneurship causes urban growth.[2]

We tackle this problem by using an idea suggested in Chinitz's original account. Chinitz claims that Pittsburgh's dearth of entrepreneurs reflected its historical concentration in steel, which in turn reflected proximity to large deposits of coal and iron ore (White, 1928). The steel industry has significant returns to scale, and Chinitz argues that its presence crowded out more entrepreneurial activities. This left Pittsburgh with an abundance of company men but few entrepreneurs. Moreover, Chinitz emphasizes how this dampening of entrepreneurship comes through both static factors (e.g., access to inputs for new businesses) and dynamic factors (e.g., the intergenerational transmission of skills from parents to children).

We systematically investigate the connection between historical mineral and coal deposits and modern entrepreneurship. There are returns to scale in many extractive industries and their industrial customers, not just coal and steel. The process of bringing ores out of the earth is a capital-intensive operation that often benefits from large scale operations. Transforming and transporting ores also typically requires large machines and production facilities. Therefore, we hypothesize that cities with an historical abundance of nearby mineral and coal mines will have developed industrial structures with systematically larger establishments and less entrepreneurship. These early industrial traits can in turn influence modern entrepreneurship through persistence and intergenerational transmissions that we elaborate on further below.

[1] Acs and Armington (2006) provide a broad overview of U.S. spatial patterns for entrepreneurship and economic growth. Ghani, Kerr and O'Connell (2010) document similar patterns across regions and industries in India. Miracky (1993) further extends the work of Glaeser et al. (1992).

[2] Further progress has been made in establishing causal links of entrepreneurial finance to industry or city growth (e.g., Kortum and Lerner, 2000; Samila and Sorenson, 2010). It is striking, however, that similar progress has not been achieved for entrepreneurship overall.

We use the existence of mineral and coal deposits in 1900 as our measure of the returns to mining around a city. These data comes from the historical records of the U.S. Geological Survey and economic censuses at the time. Figure 2 is a representative map. We demonstrate that a city's historical proximity to mineral and coal deposits is strongly correlated with larger average establishment size for manufacturing in 1963 and subsequently. These deposits are also associated with larger average establishment size in quite unrelated industries in the 1970s and 1980s (initial years for sectors are determined by our Census Bureau data). While the relationship is most pronounced in industries that have more occupational overlap with mining, historical deposits are associated with larger establishment sizes throughout the city. These patterns are very similar for other measures of modern entrepreneurship like local employment in start-up firms.

With this background, we use historical mineral and coal deposits as an instruments for our modern entrepreneurship variables. We continue to find a strong connection between a city's entrepreneurship and subsequent economic growth. A one standard deviation decrease in average initial establishment size for a city is associated with about a 0.9 standard deviation higher employment growth between 1982 and 2002. Similarly, a one standard deviation increase in the initial employment share of start-up firms is associated with a 0.4 standard deviation increase in urban employment growth over the next two decades. These estimates are somewhat higher than ordinary least squares estimates, but the differences are typically not statistically significant.

Our primary concern with these results is that mineral and coal deposits are likely associated with other variables that can impact economic growth. For example, these correlations may reflect a general decline in U.S. employment in extractive industries or the decline of Rust Belt regions. We address the first concern by separately considering industries that are quite different from mining, such as trade, services, and finance. We find that our results are, if anything, stronger for these sectors of the economy. Proximity to mines in 1900 predicts larger establishments, less entry, and less urban growth in financial services today.

Sector decompositions do not address the possibility that our results simply reflect the general decline of cities that were initially built around natural resources. The decline of the steel industry in Pittsburgh did not just impact steel production, but also the financial and service firms that catered to that industry and its employees. We have do not have a perfect fix for this problem, but one approach is to focus on the U.S.'s growing regions. Manufacturing does not predict strong urban decline in the warmer regions of the U.S., which have been witnessed the most substantial growth, and yet we still find that historical mines predict dampened employment growth. A further refinement focuses only on highly agglomerated industries within trade, services, and finance. Highly concentrated industries frequently have wide product markets and thus are less influenced by local demand. We demonstrate that our results hold when only considering highly agglomerated trade, services, and finance industries in warmer areas.

This stability suggests that mines did influence modern entrepreneurship, and that our results have a much deeper foundation than U.S. regional evolution. Nevertheless, historical mineral and coal deposits are an imperfect instrument. They will have some correlation with other local variables besides entrepreneurship, and so our conclusions must be tentative. Yet empirical work on entrepreneurship and urban economics must begin identifying and exploiting exogenous sources of local entrepreneurship. Historical mines are one such instrument, imperfect as they may be. Our work represents a first stab at trying to find exogenous sources of variation in local entrepreneurship and using that variation to examine whether the strong correlations between city employment growth and entrepreneurship hold when removing the most worrisome endogeneity. The general conclusion from this exercise is that entrepreneurship is systematically related to local employment growth.

The plan of this paper is as follows. Section 2 reviews the Chinitz hypothesis and related literature. Section 3 introduces our data, and Section 4 establishes basic facts about entrepreneurship, average establishment size, and urban employment growth. Section 5 then describes in greater detail the first stage relationships between historical mineral and coal deposits and modern entrepreneurship. Section 6 presents the instrumental variable results, and Section 7 concludes.

2 Entrepreneurship, Establishment Size and Mining

The core hypothesis of the literature on entrepreneurship and city growth is that some places are endowed with a greater number of entrepreneurs than others and that this endowment of entrepreneurial human capital influences economic success. Chinitz (1961) first formulated this hypothesis in his attempt to explain why post-war New York was experiencing more economic success than post-war Pittsburgh. In a sense, this entrepreneurship hypothesis is a close cousin of the literature relating local human capital levels to area development and growth (e.g., Glaeser et al., 1995; Simon, 1998; Simon and Nardinelli, 2002). While the latter human capital literature typically focuses on formal education as the measure of human capital, entrepreneurial skill is another important form of human knowledge that seems a priori as likely to explain area success as any other type of skill.

The literature on entrepreneurship and local economic growth typically uses two different measures of entrepreneurship, neither of which are perfect. Perhaps the most common choice is average establishment size, which is readily available in public data sources like County Business Patterns. Small establishments would seem to be a natural measure of ratio of the number of establishment heads, who may be entrepreneurs, to employees. Micro-data studies, on the other hand, often emphasize that young and entering establishments generate more job growth than small establishments.[3] Thus, a second measure of entrepreneurship is the share of local employ-

[3] For example, Davis, Haltiwanger and Schuh (1996) and Haltiwanger, Jarmin and Miranda (2010).

ment that is in new start-up firms. While the latter metrics capture more of the dynamic nature of entrepreneurship, they also frequently require access to confidential micro-data. Nevertheless, these two measures are correlated with each other across cities, and both have been shown to be correlated with local employment growth.[4]

Glaeser et al. (1992) find a link between small establishment size and sectoral employment growth between 1956 and 1988. Their basic approach is to look at city-industries—industrial groups within cities—and they observe that city-industries with smaller average establishment sizes grew more rapidly. Glaeser, Kerr and Ponzetto (2010) follow this work using the Longitudinal Business Database and find that the correlation is extremely strong and robust. The patterns hold with city and industry fixed effects and across a broad range of industries and regions. They also observe that areas with small establishment sizes do not seem to have higher returns to entrepreneurship, which supports the idea that cities differ sharply in their supply of entrepreneurs.

But while it is clear that some cities and city-industries have much larger average establishment sizes, and that employment growth is lower where establishments are bigger, it is less clear why establishment sizes differ spatially. Glaeser, Kerr and Ponzetto (2010) interpret their results as meaning that clusters of entrepreneurship exist, but they are unable to explain why they exist where they do. Without adequate sources of exogenous variation in entrepreneurship, it is impossible to be sure that the measured growth effects of entrepreneurship really represent the causal effect of entrepreneurship or whether there are other factors that lead cities to both more growth and more entrepreneurship.

Our approach to this problem starts with Chinitz's claim that industrial history drives the level of entrepreneurship in a city. Chinitz argues that New York's historical garment industry—the nation's largest post-war industrial cluster—was a natural training ground for entrepreneurs. The garment trade had few serious fixed costs or scale economies, and as a result there were a large number of small entrepreneurs in the industry. Chinitz argued that this entrepreneurship in turn influenced neighboring industries.

Indeed, there are many anecdotes about entrepreneurs who began in the garment industry and then branched into other industries (or bred entrepreneurial children). For example, A. E. Lefcourt was New York's greatest skyscraper builder in the years before the Great Depression. Lefcourt got his start in the garment trade, where he was able to scrape together enough capital from his savings and by borrowing from his customers to buy a garment company from his boss at the age of 25. The father of Sanford Weill, an entrepreneurial engine in New York's finance industry from the 1960s to the 1990s, also started as a garment entrepreneur. These stories support Chinitz's contention that entrepreneurial human capital may actually be transmitted from parent to child.

[4]Self employment is a third possible measure of entrepreneurship. While it is correlated with average establishment size across metropolitan areas (Glaeser and Kerr, 2009), it is considered to be a very noisy measure and has little correlation with economic growth. As such, we do not use it in this study.

By contrast, Chinitz depicts Pittsburgh as a city of company executives who did not want nor could have inculcated entrepreneurial talents in their children. Chinitz suggests the roots of this big company mentality came from Pittsburgh's dominant steel industry. The steel industry was dominated by a few large firms, most notably U.S. Steel, which produced 66 percent of ingot production in 1901 and 42 percent in 1925 (Stigler, 1925).[5] U.S. Steel, of course, had its roots in the scrappy start-ups of Andrew Carnegie and others, but by the early decades of the 20th century, it had become essentially synonymous with corporate bigness. Chinitz (1961) then argues:

> My feeling is that you do not breed as many entrepreneurs per capita in families allied with steel as you do in families allied with apparel, using these two industries for illustrative purposes only. The son of a salaried executive is less likely to be sensitive to opportunities wholly unrelated to his father's field than the son of an independent entrepreneur. True, the entrepreneur's son is more likely to think of taking over his father's business. My guess is, however, that the tradition of risk-bearing is, on the whole, a more potent influence in broadening one's perspective.

In Chinitz's view, the "Salaried Executives" of U.S. Steel were just less likely to inculcate entrepreneurial talents and inclinations in their children, which in turn made Pittsburgh less entrepreneurial for years to come.

Chinitz certainly seems to be right about intergenerational transmission of entrepreneurship (Blau and Duncan, 1967). Hout and Rosen (2000) document that "the primary family factor effecting an individual's self-employment status is the self-employment status of his or her father." They show that self-employment rate for sons of self-employed fathers is about twice as high as the self-employment rate for sons of employees. The intergenerational transmission of entrepreneurial human capital makes it possible that industrial history could still impact the level of entrepreneurship today. The likelihood of this persistence is supported by empirical studies that show that entrepreneurs are more likely to be from their region of birth than wage workers, and that local entrepreneurs operate stronger businesses (e.g., Figueiredo, Guimaraes and Woodward, 2002; Michelacci and Silva, 2007; Dahl and Sorenson, 2007).[6]

[5] Stigler's famous piece on U.S. Steel emphasizes that the creation of this company brought massive returns to investors because of its ability to exploit monopoly power.

[6] Chinitz documents a broad list of reasons for why entrepreneurial advantages would descend from small incumbent firms in city. In addition to the intergenerational mechanism, Chinitz discusses social standing more broadly, suggesting that an "aura of second class citizenship" surrounds entrepreneurship in cities dominated by big firms. Chinitz also notes capital constraints: small firms are more likely to redeploy capital in their local area than large firms, and financial institutions are also more likely to serve small firms in cities with more small firms. These patterns have been subsequently observed in multiple entrepreneurial finance studies. Chinitz further emphasizes labor constraints, as large firms are more likely to locate out of the center city, which makes spousal employment harder. Finally, and perhaps most famously, Chinitz emphasizes access to intermediate goods. Small firms have many needs that must be satisfied by the local economy. Large incumbent firms often source inputs internally or at a distance. This can depress external supplier development. Moreover, similar to capital providers, it then becomes harder for new entrants to gain the attention of existing suppliers that are serving large firms in the area. These additional factors also make it harder for entrepreneurship to get underway in a city with large incumbent firms.

To find exogenous variation in a city's industrial past, we turn to mineral and coal mines. The U.S. Geological Survey has been documenting the existence of such deposits for over a century, and we are able to determine whether deposits exist near any given city. We hypothesize that these deposits were generally associated with bigger establishments and firms, just as coal mines were with U.S. Steel in Pittsburgh, and that those bigger establishments crowded out smaller enterprises and entrepreneurship.

Why would mines generally be associated with larger establishments? Mining itself appears to have substantial returns to scale, probably because of the large fixed investments required to drill, mine and ship heavy products like ore and coal. In 2008, County Business Patterns documents that the average establishment size across the entire U.S. is fewer than 16 people. By contrast, the average coal mining establishment has 74 people. The average iron ore mining establishment has 209 workers, and the average establishment in "copper, nickel, lead and zinc mining" establishment has 193 workers. It certainly appears that mining itself is conducive to large establishments, perhaps even more so than the documented accounts for coal mining.[7]

Pittsburgh's example suggests that manufacturing establishments that then use the products of mines are also large, perhaps because industries that use large amounts of coal or ores have large scale economies associated with big plants. In 2008, the average establishment in primary metal manufacturing had 85 employees, which is more than double the 40 employee national average for manufacturing as a whole. As such, it is plausible that an abundance of mineral and coal deposits lead to large establishments in a particular area and that these large establishments meant that typical workers became skilled at working in big firms, not at starting their own companies.

Our identification strategy builds on the exogenous spatial distribution of mineral and coal deposits in 1900. We first link these deposits to average establishment sizes and entrepreneurship in the 1960s and onwards. If Chinitz is right that big firms reduce the stock of entrepreneurial capital, then these deposits should lead to larger average establishment sizes in closely related industries, such as primary metal manufacturing, and also in less related sectors like services and finance. We then investigate whether the places and sectors that have large average establishment sizes—because of proximity to mineral and coal deposits—experience less growth during the modern era.

3 Data Description and Empirical Approach

This section describes our core data sources and empirical methodology. We develop our urban growth and entrepreneurship metrics through confidential data housed by the US Census Bureau. Our primary data source is the Longitudinal Business Database (LBD). The LBD provides

[7] In 1919, the average employee counts are similarly high: all mines (77), anthracite coal mines (508), bituminous coal mines (82), and iron ore mines (158). Calculations are made using the 1930 Statistical Abstract of the United States, Table 733.

annual observations for every private-sector establishment with payroll from 1976 onward. The only excluded sector is agriculture, forestry and fishing. In addition, we draw some statistics from the Census of Manufacturers, which extends back to 1963. Unfortunately, data for other sectors are only available starting in 1976.

The Census Bureau data are an unparalleled laboratory for studying the industrial structure of US firms. Sourced from US tax records and Census Bureau surveys, the micro-records document the universe of establishments and firms rather than a stratified random sample or published aggregate tabulations. In addition, the LBD lists physical locations of establishments rather than locations of incorporation, circumventing issues related to higher legal incorporations in states like Delaware.

The comprehensive nature of the LBD also facilitates complete characterizations of entrepreneurial activity by cities, industries, types of firms, and so on. Each establishment is given a unique, time-invariant identifier that can be longitudinally tracked. This allows us to identify the year of entry for new start-ups or the opening of new plants by existing firms. We define entry as the first year in which an establishment has positive employment. Second, the LBD assigns a firm identifier to each establishment that facilitates a linkage to other establishments in the LBD. This firm hierarchy allows us to separate new start-ups from facility expansions by existing multi-unit firms.

As a representative year, the data include 108 million workers and 5.8 million establishments in 1997. During the 1990s, there were on average over 700,000 entering establishments each year that employed more than seven million workers. The average start-up included ten workers, and notably there were very few entering mining establishments during this period (less than 0.5% of entrants).

Our core estimations examine urban growth and entrepreneurship from 1982-2002. We have manufacturing data going back to 1963, but we focus primarily on the period for which our data covers all sectors of the U.S. economy.[8] This will enable use to run regressions of the form

$$\ln\left(\frac{\text{Employment}_{c,2002}}{\text{Employment}_{c,1982}}\right) = \beta \cdot \ln(\text{Entrepreneurship}_{c,1982}) + \text{Other Controls}_c + \varepsilon_c, \qquad (1)$$

where c indexes cities. We will use this same empirical design with industrial subsets of metropolitan areas. Our controls are taken from the urban growth literature and include typically include initial employment, census division controls, and other city-level variables like average January temperature, the share of adults with college degrees, and initial housing prices.[9]

[8] We start our estimations in 1982, rather than in 1976, to be conservative. The period before 1982 includes a substantial amount of economic change and restructuring. Including this period leads to stronger results than those we present below, but we want to be conservative in our approach. Also, the LBD currently extends to 2005. We find very similar results when looking at total city employment growth until 2005. The Census Bureau, however, moves from the SIC industry classification system to the NAICS system in 2002. As this transition complicates many of our sector-level decompositions, we end the sample period in 2002.

[9] We define cities by mapping counties in the LBD to Primary Metropolitan Statistical Areas (PMSAs). We exclude cities in Alaska and Hawaii due to our spatial instrument variable estimations. We also exclude some

The β coefficient describes the correlation of initial entrepreneurship and subsequent employment growth for the city. As in much of the previous research in this area, we focus on growth of employment rather than growth in wages, since wage growth should be limited by the mobility of workers across space. Entrepreneurs may, in addition, be able to succeed by limiting the wages received by the workers, so per capita wage growth is not necessarily a sign of local entrepreneurial success.

Our core measures of entrepreneurship are average establishment size in 1982 and the share of employment in start-ups in 1982-1986. We take the average over several years for the second metric to smooth out business cycles and the data collection patterns of the Census Bureau, but this is not an important factor. Average establishment size is defined as the number of employees divided by the number of establishments. It includes both single-unit firms and multi-unit establishments. We define the share of employment in start-ups on an annual basis using the entry rate of new single-unit firms. This approach quantifies gross entry levels, rather than the net entry that would be observed by looking at changes in establishments between two points.

Table 1a provides summary statistics for cities and entrepreneurship related to our sample. The average city had 233 thousand employees in 1982 among sectors covered by the LBD. We will generally consider two large subsectors of the economy: "mining, construction and manufacturing" (which should be directly influenced by mining opportunities) and "trade, finance and services" (which should not make any direct use of coal or mineral ores). On average, a little less than three quarters of city employments are in trade, finance and services. The average city experiences employment growth of 0.34 log points, or 43 percent, from 1982-2002. Reflecting national industrial trends, this employment growth is much higher in trade, finance and services (0.44) than in mining, construction and manufacturing (0.06). The average establishment has 19 employees, with substantially larger establishment sizes in mining, construction and manufacturing (34) than in trade, finance and services (16). About three percent of employees in a city are in entering firms.

Table 1b shows the correlation between these different measures of entrepreneurship. The first column shows the correlation between average establishment size and other measures of entrepreneurship. The first two rows show the connection between overall establishment size and establishment size within the two subsectors. The correlation between the overall measure and the first ore-oriented subsector variable is 0.62; the correlation with average establishment size in trade, finance and services is 0.74. The second column shows that the correlation in average establishment size between the two subsector level variables is more modest at 0.14 (although statistically significant at a 10% level).

small PMSAs that are not separately identified in the Census of Population (required for explanatory variables). Results below are robust to instead considering Consolidated MSAs. CMSAs are subdivided into PMSAs for very large metropolitan areas (e.g., Chicago has six PMSAs within its CMSA). A PMSA is defined as a large urbanized county or a cluster of counties that demonstrate strong internal economic and social links in addition to close ties with the central core of the larger area.

The third row in the first column shows the robust correlation between our two measures of entrepreneurship. Average establishment size in a city has a -0.49 correlation with the city's share of employment in start-up ventures. That is, cities with smaller establishments also have more employment in entering establishments. The fourth column shows the relationship holds when instead counting the share of establishments in a city that are start-ups. The final row shows that we find almost identical results to average establishment size when instead looking at the employment share in establishments with fewer than 20 employees, which is to be expected. The strong correlation between start-up employment and average establishment size is the topic of Glaeser, Kerr and Ponzetto (2010), who take it to suggest the existence of clusters of entrepreneurship.

The next two columns show the relationship between average employment size in the two industrial groups and other measures of initial entrepreneurship. Average establishment size in mining, construction and manufacturing is robustly correlated with start-up shares in the other variables. The correlation between average establishment size in trade, finance and services and the start-up shares is much weaker. Our empirical results focus on average establishment size and employment shares in start-up firms. We find very similar results when using these additional variants.

4 OLS Relationship of Entrepreneurship and Local Growth

4.1 City Growth Regressions

We quantify the basic relationship between local entrepreneurship and subsequent urban employment growth. Equation (1) is our core empirical specification, but we also report results for growth in total payroll and wages. Panel A shows results using average establishment size in 1982 as our measure of entrepreneurship, while Panel B uses the initial share of employment in start-ups. Estimations are unweighted, have 291 observations, and report standard errors clustered by the nine census divisions.[10] To guard against excessive outliers, we cap variables at their 2% and 98% values.

The first regression in Panel A shows the strong negative relationship between employment growth over 1982-2002 at the metropolitan area level and initial establishment size. A 0.5 increase in the logarithm of 1982 establishment size (approximately 40 percent) is associated with a 0.28 log point decrease in the growth of employment over the ensuing 20 years (approximately 25 percent decline). Panel B finds that a 0.5 log point increase in the share of initial employment in start-ups is associated with a 0.1 log point (approximately ten percent) increase in urban employment growth over the next 20 years. These effects are economically large and statistically significant, which is why it makes sense to further refine and test these correlations between

[10] We find similar standard errors when bootstrapping. In future work, we intend to more systematically model spatial autocorrelation.

entrepreneurship and local job growth.[11]

The second column shows that these coefficient estimates are essentially unchanged by including controls for the log level of initial employment in the city, its square, and fixed effects for the nine census divisions. This stability suggests that the correlations are not simply a product of mean reversion or differences in U.S. regional growth.

The third column shows that these coefficients are also essentially unchanged if we also include standard controls for city growth from the urban growth literature: mean January and July temperatures, the 1970 share of workers with college degrees, the 1970 population level and density of the city, and 1970 housing prices. These factors control for documented phenomena like population growth over the last three decades in warm places and the rise of the skilled city. The fact that these controls have so little impact on our entrepreneurship measures suggests that these measures are unlikely to be proxying for core attributes of the urban area.[12]

Columns 4-6 repeat these results using payroll growth as the dependent variable. Some of the coefficients are slightly smaller, but the overall picture remains the same. Metropolitan areas with more initial employment in start-ups or smaller average establishment size experienced faster payroll growth between 1982 and 2002. Other local controls have little effect on the core results.

In line with the symmetry of employment and payroll growth, Columns 7-9 confirm that initial entrepreneurship is not associated with subsequent wage growth nor declines. Entrepreneurship generates more job growth for cities, but not faster earnings growth for those employed. One interpretation of these results is that a spatial equilibrium exists across cities, and this equilibrium limits the tendency of any city's wages to rise much faster than its peers (Glaeser and Gottlieb, 2009). A second interpretation is that entrepreneurs have very lean operations that minimize labor costs, putting downward pressure on wage growth for workers. This latter effect could be due, for example, to entrepreneurs operating in more competitive environments.

4.2 Sample Decompositions

Tables 3a and 3b repeat our results for employment growth within various subsets of our data. These exercises only adjust the outcome variable in specification (1); entrepreneurship variables are still defined at the city level. The first column of Table 3a repeats our core regression looking at employment growth in mining, construction and manufacturing. The results for average establishment size remain strong; the results for start-up employment shares become smaller and statistically insignificant. The second column shows that both measures are significant for trade,

[11] These results are quite robust to how the growth metric is defined, such as measuring growth relative to average city employment over 1982-2002 (e.g., Davis, Haltiwanger and Schuh, 1996). Similarly, non-parametric approaches that include indicator variables for quintiles of average establishment size demonstrate regular treatment effects with the most substantial change occurring between the second and third quintiles.

[12] The results are further robust to additional covariates like Saiz's (2010) geographic features of cities or using hedonic regressions to model climate amenities. We lose several cities in these extension due to data availability, however, so we focus on the narrower set.

finance and services, although the start-up employment share has again lost about a third of its economic magnitude. At the city level, average establishment size appears the more robust correlate of subsequent employment growth across sectors.

Columns 3-5 in Table 3a separate employment growth by the degree of industrial agglomeration. We split industries by their national level of agglomeration as measured by the Ellison and Glaeser (1997) index. That index looks at the lumpiness of employment across space, correcting for the overall spatial distribution of economic activity and the tendency of industries with big establishments to be more highly concentrated geographically. Our results are strongest for the most agglomerated industries, and we have confirmed these patterns hold when defining industry agglomeration through the Duranton and Overman (2005) index. These results suggest that entrepreneurship may be most important for industries that have the most powerful interactions among clustered firms. They also suggest that our results extend well beyond the growing demand of home markets.

The first two columns of Table 3b show results by two broad regions of the U.S. The first column considers colder cities, defined by having a mean January temperature less than 34 degrees. This cut-off point is approximately the median January temperature in the sample. These cities have a longer industrial history and experienced slower growth (or in some cases decline) over our time period. This sub-sample includes the complete Rust Belt. The second column shows results for warmer regions, which experienced stronger population growth between 1982 and 2002. Comparing the two columns suggests that entrepreneurship has a stronger associated with city growth in colder regions of the U.S., although the differences across regions are not statistically significant. We further utilize this decomposition below.

Columns 3 and 4 in Table 3b separate our data into two periods. The results are stronger during the 1982-1992 period than during the 1992-2002, although the differences between the two periods are not statistically distinct. The link between entrepreneurship and urban growth is statistically significant in both periods, excepting the start-up birth share in 1992-2002, which suggests that the connection is a lasting phenomenon. Appendix Table 1 further reports the full apparatus of Table 2 separately for these two periods.

4.3 City-Industry Growth Regressions

While the correlation between entrepreneurship and urban employment growth for cities is quite strong and robust to covariates, our confidence in this link is also based upon its strength across industries within cities. Table 4 illustrates these connections. We define industries at the two-digit level of the Standard Industrial Classification system. To focus on meaningful variation, we require that industries have 100 employees throughout the period. This results in 12,178 observations. We continue to cluster standard errors by region.

Panels A and B again provide the results using average establishment size and start-up employment share, respectively. We refine our initial employment controls to be city-industry specific. We further include industry x census division fixed effects in all specifications. These fixed effects account for the overall employment growth rate and entrepreneurship levels of each industry and region. The first column models the basic city growth covariates also used in Tables 3a and 3b. In the second column, we instead include city fixed effects. In the latter case, our variation is restricted to within-city differences. We thus look for connections of initial entrepreneurship to subsequent employment growth after removing overall patterns by city and by region-industry. This is a very stringent test of the relationship.

The correlation between our entrepreneurship measures and subsequent employment growth is typically smaller at the city-industry level. In the first column, we find that a 0.5 log point decrease in average establishment size is associated with a 0.10 increase in subsequent employment growth for the city-industry. A 0.5 log point increase in the share of employment in start-ups is associated with a 0.03 log point increase in subsequent employment growth. These effects are statistically significant and economically meaningful. The second column shows that these effects are essentially unchanged when we switch from city growth controls to city fixed effects.

These results suggest that the employment-entrepreneurship link is quite strong within cities, but that the effects are somewhat weaker than at the metropolitan area level. One explanation for the weakening of the effect is that perhaps entrepreneurship is proxying for other city-level attributes. Another explanation is that there are cross-industry spillovers from entrepreneurship, as suggested by Chinitz's hypothesis about a local culture of entrepreneurship.[13]

Table 5 considers subsamples of the city-industry data; all estimations include the most stringent city and industry x census division fixed effects. The first two columns again separate industry groups. The relationship between entrepreneurship and employment growth is robustly present in both groups, being stronger for the mining, construction and manufacturing cluster than for the trade, services and finance cluster. These results confirm our earlier findings for cross-metropolitan area employment growth, and they show power where the aggregate growth effect was weaker.[14]

Columns 3 and 4 show similar results in colder and warmer regions. Columns 5 and 6 again find similar results by decade. Overall, the many city-industry disaggregations and other unreported tests show the deep empirical association between initial entrepreneurship and subsequent growth. This association is more stable across decompositions at the city-industry level than at the city level.

[13] Evidence for these cross-industry links have been identified in micro-data studies of the Chinitz effect like Drucker and Feser (2007), Glaeser and Kerr (2009), Glaeser, Kerr and Ponzetto (2010), and Rosenthal and Strange (2003, 2010). Saxenian (1994), Davidsson (1995), Hofstede (2001), Lamoreaux, Levenstein and Sokoloff (2004), Landier (2006), and Falck, Fritsch and Heblich (2009) are examples of work on entrepreneurial culture.

[14] There is a subtle but important difference between the industry disaggregations in Tables 3a and 5. In Table 3a, we maintain the same city-level entrepreneurship metrics to predict employment growth for both groups. In Table 5, the entrepreneurship measures are city-industry specific by definition.

5 Historical Mines and Modern Entrepreneurship

While these patterns are provocative, we remain troubled by the endogenous nature of initial entrepreneurship. An abundance of start-ups in a particular city may simply reflect unmeasured city level attributes that make both entrepreneurship and future job growth more feasible. Perhaps the concentration of entrepreneurship in particular city-industries just reflects greater opportunities within that local economic sector or unobserved policy interventions. While the stringent tests above create a high bar for these alternative explanations, there is still a need to identify in this literature an exogenous source of variation in entrepreneurship. To address these issues, we now turn to the historical presence of mines close to each city.

We identify the location of mines from the U.S. Geological Survey (USGS) database.[15] This survey provides data on present and past mines, including their discovery date and spatial location. We focus on mines that were known to exit in 1900.[16] We believe that this survey provides a relatively complete survey of coal and ore availability at the start of the 20th century. This survey is somewhat preferable to using the spatial output of operating mines during this period. The former reflects better the true natural availability of underground wealth during that era, while actual output levels may be endogenous to manufacturing activity at the time.

Congress established the USGS in 1879 and chose the indefatigable Clarence King to be its first director. John Wesley Powell, a geology professor and former military engineer, shortly replaced him and continued his work exploring the American west. Deposits were a great source of wealth, and the government took its surveying responsibilities seriously. While it is possible that mineral and coal deposits were more likely to be discovered in areas that were more heavily inhabited or used for manufacturing during the 1800s, maps like Figure 2 certainly suggest that the Geological Survey was doing a good job of surveying the entire U.S. In the 1800s, prospecting often preceded industry, as it had for example in the California Gold Rush or the later Black Hills Gold Rush. Long before the upper peninsula of Michigan was well settled, the state government had sent pioneering geologist Douglass Houghton to survey the area. Houghton would help establish the copper and iron ore deposits in the region. Likewise, a 1908 report already identifies the four largest coal deposits to be in Colorado, Montana, North Dakota and Wyoming, followed by West Virginia and Illinois, despite the fact that formal extraction at the time in Pennsylvania was an order of magnitude higher than any other state.[17]

But while the USGS's identification of mines is relatively straightforward, it is less obvious how to transform these data for our empirical exercises. The USGS, for example, identifies

[15] These data are available and described at http://tin.er.usgs.gov/mrds/about.php. Unfortunately, researchers should be aware that most fields beyond location and commodity type are unavailable for a large fraction of the mines.

[16] The USGS data do not contain the discovery date for many mines. We do not believe this a significant factor for two reasons. First, we obtain even stronger results if we use the full mining data regardless of discovery date. Second, we obtain comparable results when using published reports at the state level of estimated coal and iron ore mineral reserves from the 1910 Statistical Abstract of the United States.

[17] See 1910 Statistical Abstract of the United States, Table 12, and 1930 Statistical Abstract of the United States, Table 767.

the location of deposits, not the size of those deposits. Moreover, minerals are durable and easy to ship. Indeed, the relocation of some steel production from Pittsburgh to Buffalo in the early 20th century reflected the ease of moving coal from Pennsylvania to New York and Buffalo's location on the shipping routes for iron coming from the west. Railroads and water transportation were quite strong by this period (e.g., Field 2010), and the average price per ton-mile had declined from 6.2 cents in 1833 to 0.7 cents in 1900 (Carter et al., 2006). These and related facts indicate that mines do not need to be immediately proximate to cities to influence their industrial structures.[18]

Our core results employ as an instrument the logarithm of the number of mineral and coal mines within 500 miles of the geographic centroid of the city in 1900. Cities have on average 943 mines in this spatial range, ranging from a minimum of ten to a maximum of 2966. We find very similar results when weighting mines by the number of different types of ores that they extract. We use the logarithm to allow for concavity in the impact of total mine counts.

We also test two instruments that further describe attributes of the mines related to coal and iron ore. The first instrument is an indicator variable for whether coal and iron ore is the dominate mining product of a state in 1928. We take this measure from the 1930 Statistical Abstract of the United States. Our second measure is the count of iron ore mines within 100 miles of the city in 1900. While every U.S. city is within 500 miles of at least one mine, more than a third of cities do not have an iron ore mine within 100 miles. We thus use the levels of this variable directly. Appendix Table 2 provides additional descriptive statistics on our mining data.[19]

It is important to again note that estimations include fixed effects for the nine census divisions, such that we identify only off of city differences in proximity to historical mining deposits within each region. Levels differences across the nine census divisions account for about a quarter of the total variation across cities. This regional explanatory power is similar when using a 100 or 250 mile radius. We also continue to cluster standard errors by census division.

Table 6 shows that our mining metric strongly predicts entrepreneurship late in the 20th century. Column headers indicate outcome variables, and the regressions also control for census division fixed effects, initial employment, and city growth covariates. Panel A reports estimates with the log count of mines within 500 miles as the central explanatory variable. As the covariates are the same variables that will be included in our final regressions, Columns 3 and 6 thus represent first stage relationships. Panel B and C add additional traits related to the types of mines around the city.

[18] The economic history accounts of whether natural advantages or market access determined the spatial placement of large-scale manufacturing by 1900 are mixed. See Krugman (1991), Kim (1995), and Klein and Crafts (2009). Related work on industry location and natural advantages includes Ellison and Glaeser (1999), Kim (1999), Rosenthal and Strange (2001, 2004), Glaeser and Kerr (2009), Holmes and Lee (2010), Ellison, Glaeser and Kerr (2010), Kerr and Kominers (2010), and Bleakley and Linn (2010).

[19] We will refine both of these measures in future work, which are somewhat limited currently by the comparability of our coal mine data in the USGS database.

The first regression on Panel A shows the connection between the number of mines and the average establishment size in manufacturing in 1963. We do not have data for a wider range of industries during that year. As the number of mines increases by one log point, the average establishment size in manufacturing increases by 0.21 log points (approximately 24 percent). This relationship is both statistically significant and economically relevant. The t-statistic is about three. We have also confirmed that mines in 1900 are associated with weaker entrepreneurship for manufacturing in the 1960s.

The second regression shows the strong relationship between historical mines and mining activity at the start of our time period. A one log point increase in the number of mines is associated with a 1.16 log point increase in mining employment near the city over 1976-1980. These deposits certainly still matter for the industrial composition of an area.

The third regression looks at the relationship between historical mining deposits and average establishment size in 1982, the relevant year for our instrumental variables estimations. The estimated elasticity is 0.075, which means that as the number of mines increases by one log point, average establishment size increases by about eight percent. The t-statistic of this effect is more than five. Unreported regressions find that the similar effect for 1992 weakens by about a quarter but remains quite significant.

The fourth and fifth columns show the relationship to average establishment size in the two sectors. The estimated elasticity is three times higher in mining, construction and manufacturing than in trade, finance and services. A one log point increase in the number of mines raises average establishment size in closely related sectors by 15 percent and in unrelated sectors by four percent. Both estimates are statistically significant. The final regression shows that historical mining deposits are also predictive of the city's start-up employment share in 1982. The overall elasticity estimate is -0.16.

Panel B extends the estimation in Panel A to also include an indicator variable for whether coal or iron ore was the top mineral product of the state. This represents a first attempt to model the types of mines that surround a city. This indicator variable is also very predictive of increases in average establishment size and reduced entry rates. This suggests that coal and iron ore deposits are especially important for large scale operations conditional on the number of mines surrounding a city.

The last panel instead reports results by two distance rings: 0-100 miles and 100-500 miles. As more than a quarter of cities do not have a mine within 100 miles, we use a levels regression that allows for zero values. Coefficients and standard errors are multiplied by 100 for visual clarity. The results with distance rings are more nuanced. For most of the outcomes variables, the presence of mines within 100 miles matters more than mines over 100-500 miles. The differences are between two and three fold. These patterns also hold when using more disaggregated bands, suggesting mostly regular declines in the impact of mines on industrial structures with greater distance.[20] On the other hand, the very localized presence of mines does not predict average establishment size in unrelated sectors of trade, finance and services. This effect comes mostly through mines in the larger spatial area around the city.

These regressions ensure that the problem with our instruments will typically not be in their first stage fit. Mines in 1900 are strongly related to establishment size and entrepreneurship at the beginning of our regression time period. Our larger concern is that mines could easily be correlated with employment growth for reasons other than initial entrepreneurship. We will address this concern after presenting our core instrumental variables results.

6 Instrumental Variables Results

6.1 City Growth Estimations

We now describe our second stage results of entrepreneurship and local growth using proximity to mines in 1900 as an instrument for entrepreneurship. Table 7a considers average establishment size in 1982 as the core independent variable, while Table 7b models initial entrepreneurship through the local employment share in start-ups. In both tables, Panel A models a single instrument variables regression with log count of mines in 1900 as the instrument. Panel B adds a second instrument of the indicator variable for dominate product type, and Panel C further expands to a triple instrument specification that also includes the count of iron ore mines with 100 miles as an instrument.

The first regression in Panel A of Table 7a shows that the effect of average establishment size on subsequent growth increases substantially when using mines as an instrument. The relevant ordinary least squares coefficient is -0.69, and this instrumental variables estimate is -0.97, which means that a 0.5 log point increase in average establishment size is associated with a -0.5 log point decrease in employment growth over 1982-2002. For Table 7b's employment share in start-ups, the coefficient increases from 0.20 to 0.55. Both estimates have t-statistics greater than 2.5. The associated diagnostic tests indicate that these instruments perform well for the full sample.

Panels B and C of each table show that the results further sharpen, and the coefficients shrink somewhat, as we incorporate the other two instruments. These results suggest an instrumented elasticity of -0.9 for average establishment size and 0.4 for start-up employment shares. The various diagnostic tests continue to perform well, with the one exception of the over identification test in Panel C of Table 7b being rejected at a 10% level. While the difference shrinks when using multiple instruments, it is still the case that the measured elasticities are higher than in ordinary least squares.

Why might the instrumental variables estimates be larger than the ordinary least squares estimates? One explanation is that the endogenous aspects of average establishment size and

[20] When using three distance bands of 0-100 miles, 100-250 miles, and 250-500 miles, the coefficients for average establishment size are 0.016, 0.022, and 0.009, respectively. Those for birth shares are -0.075, -0.045, and -0.024. All estimates are statistically significant.

new start-ups actually work against city growth, while the exogenous aspects—captured by the long run supply of entrepreneurs—have an even stronger positive effect than the ordinary least squares estimates indicate. According to this view, negative aspects of an area kill off large firms and employment in older establishments, making average establishment size smaller and the start-up share larger (e.g., pushing displaced workers into entrepreneurship). By allowing only the variation that comes from the long run supply of entrepreneurs to influence our estimates, the instrumental variables estimates correctly show a larger elasticity of long run growth with respect to entrepreneurship.

A less positive interpretation is that mines are positively associated with other aspects of the city that are connected with longer term decline. According to this view, the orthogonality condition needed for the instrumental variables condition is violated by a correlated with omitted variables and this correlation causes the instrumental variables estimates to be artificially high. We focus the rest of this paper on this potential problem.

Our next two columns show results for different regions of the country. The second column documents the colder regions, where we suspect ex ante that the omitted variables correlations are most severe. Industrial decline has been substantial within these areas, and if mines are associated with industrial variables that are not captured by our controls, then we expect our estimates to be too high. As this logic suggests, the estimated coefficients are higher in the colder regions, and we are quite skeptical about these estimates. In addition, the standard errors blow up because our wide definition of geographic area for mines provides us with little variation in the instrument. The diagnostic tests further confirm that our instruments are weak in this region.

The third column gives our results for warmer cities—regions in which manufacturing decline has been far less pronounced. In these regions, the coefficient estimates are smaller than for the nation as a whole but still large in economic magnitude. They are precisely estimated when using the multiple instruments. The coefficients are still larger in magnitude than the ordinary least square estimates, but the gap is narrower.

Since we believe that the omitted variables problems are less severe for these regions, we focus extensively on the warmer regions in later tables. While the diagnostic tests are reasonable for the average establishment size estimates in the warm region sub-sample, they are much weaker for birth employment shares. Having the full variation across U.S. cities is particularly important in the latter case. We will thus consider instrumental variable estimates for both measures of entrepreneurship when looking at the whole sample, and we will just consider average establishment size when separately analyzing warm cities by themselves.

Our final column shows results for payroll growth for the nation as a whole. The coefficients are quite similar to the instrumental variables estimates for employment growth. These estimates are again larger than the ordinary least squares estimates for payroll growth in Table 2. As employment growth and payroll growth continue to closely track each other, we do not further report this outcome below.

6.2 The Omitted Variables Problem

In Tables 8a-8c, we attempt to address the omitted variables problem by using sub-city data on employment growth. Table 8a shows our core sub-city results for the entire data sample. Table 8b shows results only for warm cities, where we believe the omitted variables problem is less severe. Table 8c separates average establishment size by sector.

The first column in Table 8a gives results for employment in mining, construction and manufacturing. This is the area where we would think that the direct effect of mines is likely to be most severe, but the effects are smaller than for overall employment growth and of borderline statistical significance. The second column gives results for employment in trade, services and finance. Despite the fact that these results would seem to be less prone to a direct effect of mines on growth, the estimated instrumental variables effects are actually larger than for the other industries and are precisely estimated. These results suggest to us that omitted variables are not driving the results. While it is certainly reasonable to believe that declines in manufacturing or mining sectors, related to the historical presence of mines, would also cause depress local employment in other industries, it is hard to believe that the effect of historical mines would be larger for those other industries than for mining itself.

The next three regressions give results by the degree of agglomeration of the industry. As before, the results are highest for the most agglomerated industries. This finding is particularly important because the degree of agglomeration is one measure of the extent to which an industry is focused on supplying the local market. Industries that focus on supplying their local customers (e.g., barbers, restaurants) tend to be ubiquitous and therefore non-agglomerated. On the other hand, industries that focus on serving a global market have less reason to spread themselves out and therefore tend to be more agglomerated (e.g., movie production, automobile manufacturers, investment bankers).

This logic pushes us to focus on the most highly agglomerated industries within the trade, services and finance sector. These agglomerated industries seem least likely to be directly influenced by any decline in local manufacturing or mining associated with the direct effect of mines. In Column 6, we find that the instrumental variables estimates of the impact of entrepreneurship are actually highest in the most agglomerated parts of trade, services and finance. This is the opposite pattern of what we would expect if the estimated entrepreneurship effects for these sectors are being driven mainly by the decline of their local markets.

Table 8b focuses just on warm cities, repeating the tests discussed in Table 8a. We again only consider average establishment size given the weak instruments problem at the regional level for birth employment shares. When using the single instrument, the employment growth in trade, finance and services has a larger point estimate than for mining, construction and manufacturing, but neither are precisely estimated. When using the triple instruments, the growth effects are very comparable and precisely estimated. Columns 3-5 give results by the degree of industry agglomeration. The growth effects are again strongest for highly agglomerated industries.

Column 6 documents one of our most important results. This column considers employment growth in highly agglomerated industries with trade, finance and services in warm cities. These regions are least likely to be compromised by omitted variables. The broad sector is not directly related to mining. And by focusing on highly agglomerated parts of that sector, we focus on those industries that are likely to depend least on local demand. Yet, our estimated coefficients are very similar as for the nation as a whole. A one log point increase in average establishment size decreases subsequent employment growth by about one log point.

Finally, Table 8c considers average establishment size by sector and that sector's employment growth. These results again highlight that most of the growth effects that we are capturing come outside of sectors traditionally dependent upon mines. While we believe that average establishment size across the whole city is the more appropriate metric, it is comforting to find similar patterns when focusing just on the trade, finance and services sectors.

7 Conclusion

The correlation between measures of entrepreneurship—such as the share of local employment in new start-ups or the average establishment size—and subsequent urban employment growth is quite robust both across and within cities. One concern with these measures is that they may capture other aspects of the local environment besides entrepreneurship. This paper tried to push forward on these issues by looking for the historical roots of small establishment sizes and higher entry rates.

We followed the intuition of Chinitz (1961), who argues that industries dependent upon mineral and coal deposits, like steel, involve large companies that create executives not entrepreneurs. We use the presence of coal and ore deposits in 1900 to provide us with variation in the level of resource intensive industries. These deposits are associated with larger establishment sizes and lower birth employment shares in the 1960s and onwards. Using this variable as an instrument, we continue to find a significant link between our measures of entrepreneurship and urban employment growth.

The big concern with this variable is that it is quite plausibly correlated with aspects of the local economy other than entrepreneurship, such as manufacturing decline. We tried to control for these factors with city level variables, region fixed effects, and so on, but we recognize that our measures are far from perfect. We focused then on industries that were not directly related to mining, and on industries that were highly concentrated spatially, which suggests that they do not depend on a local market. We also focused on warmer cities, which should be less sensitive to the decline of the Rust Belt. Our core results remain unchanged.

While we have tried to systematically address concerns about the correlation between our instrument and the error term, we remain overall cautious about the instrument and our results. We hope that further work, especially around the spatial distribution of mines, will sharpen and refine our estimates. Looking ahead, we hope that our work prompts other researchers to identify sources of exogenous variation in urban entrepreneurship, within the U.S. or outside of it. The patterns in Figures 1a and 1b are exceptionally strong and the backbone for many policy initiatives. It is remarkable given how little we know about what lies behind this relationship, especially given how central we believe entrepreneurship is for economic performance.

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Figure 1a:
Employment Growth and Firms per Worker

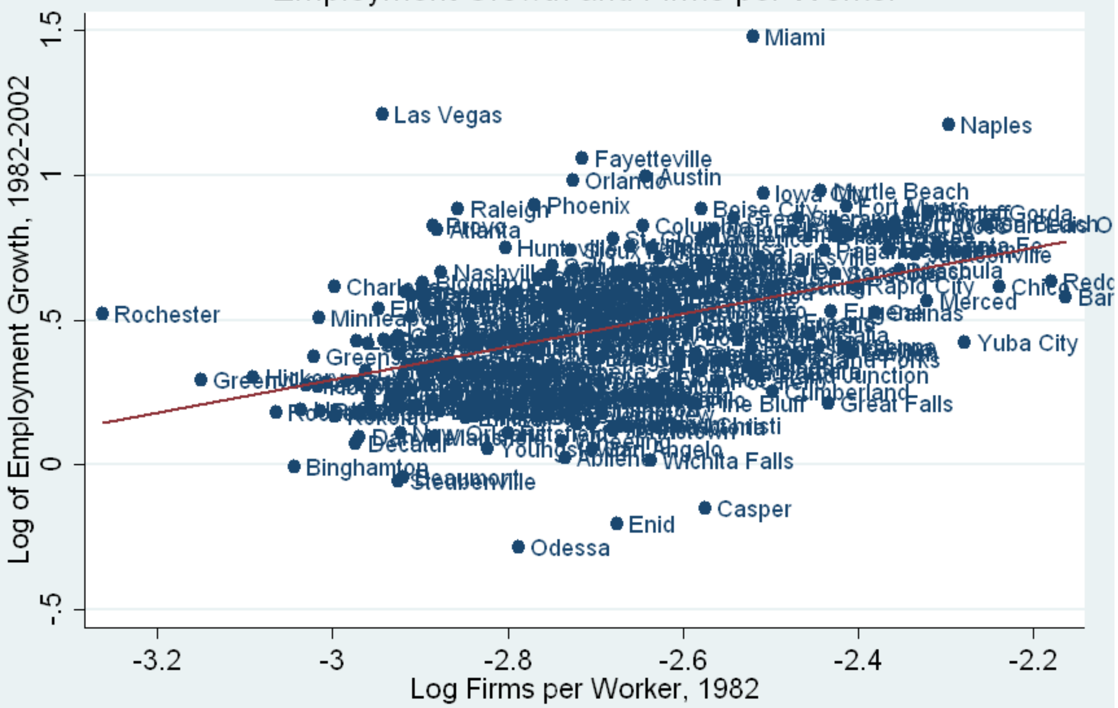

Figure 1b:
Large Cities Only

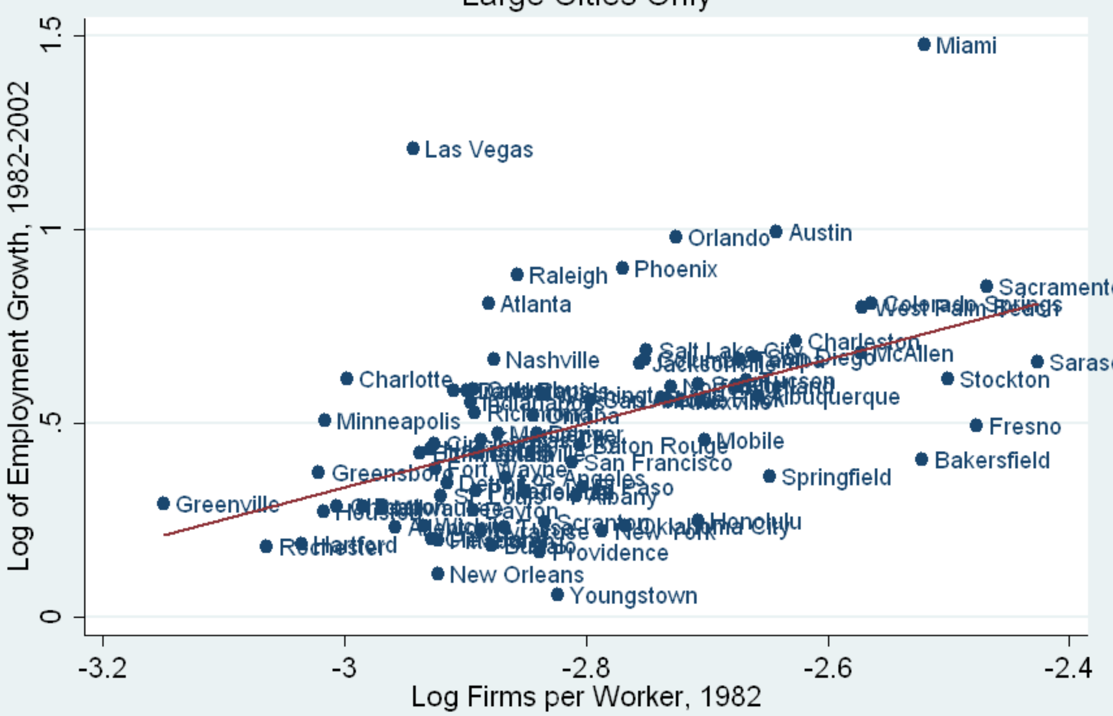

Figure 2: Representative Map of Historical Mineral and Coal Deposits

Coal and Iron Deposits in the United States, 1910
Ralph S. Tarr, B.S., F.G.S.A. and Frank M. McMurry, Ph.D., New Geographies 2nd ed
(New York, NY: The Macmillan Company, 1910)

Table 1a: LBD descriptive statistics for cities, circa 1982

	Mean	Standard deviation
City size 1982		
Total employment	231,655	411,379
Mining, construction, & manufacturers	28%	
Trade, finance, & services	72%	
Low agglomeration sectors	57%	
Medium agglomeration sectors	16%	
High agglomeration sectors	26%	
Log employment growth 1982-2002		
Overall	0.361	0.247
Mining, construction, & manufacturers	0.058	0.358
Trade, finance, & services	0.493	0.239
Low agglomeration sectors	0.440	0.233
Medium agglomeration sectors	0.358	0.297
High agglomeration sectors	0.307	0.404
Average establishment size		
Overall, 1982	19.8	3.5
Overall, 2002	19.9	2.8
Mining, construction, & manufacturers, 1982	34.1	14.2
Trade, finance, & services, 1982	15.8	3.2
Start-up share of local firm activity		
Employment, 1982	3.1%	1.6%
Employment, 2002	3.3%	1.3%
Establishment counts, 1982	9.7%	2.2%
Establishment counts, 2002	8.2%	1.7%

Notes: Descriptive statistics from the Longitudinal Business Database for 1982. Jarmin and Miranda (2002) describe the construction of the LBD. Sectors not included are agriculture, forestry and fishing, public administration, the US postal service, and private households. Start-up shares are calculated for the five-year period following the indicated date.

Table 1b: Correlations of entrepreneurship metrics across cities, circa 1982

	Average establishment size			Start-up share of local firm employments	Start-up share of local firm counts
	Overall	Mining, construction, & manufacturers	Trade, finance, & services		
Average establishment size					
Mining, construction, & manufacturers	0.62				
Trade, finance, & services	0.74	0.14			
Start-up share of local firm employments	-0.49	-0.55	-0.15		
Start-up share of local firm counts	-0.41	-0.63	-0.08	0.74	
Share of empl. in small establishments	-0.98	-0.62	-0.71	0.50	0.41

Notes: See Table 1a. Small establishments are defined to be those with 20 or fewer employees. All correlations are significant at a 10% level except the relationship between average size in trade, finance, and services and the start-up share of local firm counts.

Table 2: Entrepreneurship and growth estimations at city level, 1982-2002

	Log employment growth			Log payroll growth			Log wage growth		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				A. Measuring entrepreneurship through average establishment size					
Log average establishment size	-0.566	-0.598	-0.693	-0.435	-0.478	-0.640	0.073	0.018	-0.054
in city at start of period	(0.094)	(0.090)	(0.087)	(0.127)	(0.132)	(0.115)	(0.049)	(0.063)	(0.039)
Initial employment controls		Yes	Yes		Yes	Yes		Yes	Yes
Census division fixed effects		Yes	Yes		Yes	Yes		Yes	Yes
City growth covariates			Yes			Yes			Yes
				B. Measuring entrepreneurship through start-up employment share					
Log start-up share of employment	0.200	0.200	0.161	0.200	0.196	0.150	0.016	0.029	0.019
in city at start of period	(0.081)	(0.055)	(0.040)	(0.096)	(0.058)	(0.047)	(0.027)	(0.018)	(0.020)
Initial employment controls		Yes	Yes		Yes	Yes		Yes	Yes
Census division fixed effects		Yes	Yes		Yes	Yes		Yes	Yes
City growth covariates			Yes			Yes			Yes

Notes: Estimations describe the OLS relationship between entrepreneurship and city growth. City growth is calculated as the log ratio of employments at the end of the period to the beginning of the period. Regressions are unweighted, report standard errors clustered by nine census divisions, and have 291 observations. Initial employment controls are log employment levels at start of period and their squared values. City growth covariates include log January temperature, log July temperature, log 1970 share of workers with bachelor's education or higher, log 1970 population density, log 1970 population, and log 1970 housing prices. Nine census divisions are used in the fixed effects. A 2% trim is employed on variables. Appendix Table 1 repeats these estimations by time period.

Table 3a: Extensions to city level estimations for log employment growth

	Mining, constr., & manufacturing sectors	Trade, finance, & services sectors	Level of industry agglomeration: Low	Level of industry agglomeration: Medium	Level of industry agglomeration: High	High agglom. trade, finance, & services
	(1)	(2)	(3)	(4)	(5)	(6)
		A. Measuring entrepreneurship through average establishment size				
Log average establishment size	-0.400	-0.462	-0.387	-0.316	-0.842	-0.468
in city at start of period	(0.171)	(0.107)	(0.119)	(0.140)	(0.182)	(0.131)
		B. Measuring entrepreneurship through start-up employment share				
Log start-up share of employment	0.069	0.113	0.092	0.112	0.215	0.135
in city at start of period	(0.062)	(0.039)	(0.042)	(0.023)	(0.064)	(0.023)

Notes: See Table 2. All regressions include Initial employment controls, Census division fixed effects, and City growth covariates.

Table 3b: Extensions to city level estimations for log employment growth

	Colder cities Jan. temp <34	Warmer cities Jan. temp >34	1982-1992 period	1992-2002 period
	(1)	(2)	(3)	(4)
	A. Measuring entrepreneurship through average establishment size			
Log average establishment size in city at start of period	-0.705	-0.591	-0.432	-0.339
	(0.134)	(0.125)	(0.103)	(0.042)
	B. Measuring entrepreneurship through start-up employment share			
Log start-up share of employment in city at start of period	0.131	0.102	0.110	0.065
	(0.046)	(0.091)	(0.035)	(0.048)

Notes: See Table 2. All regressions include Initial employment controls, Census division fixed effects, and City growth covariates. Colder and warmer cities are split approximately at the median January temperature. The observation counts are 148 and 143 for colder and warmer cities, respectively.

Table 4: Entrepreneurship and growth regressions at city-industry level, 1982-2002

	Log employment growth	
	(1)	(2)
	A. Measuring entrepreneurship through average establishment size	
Log average establishment size	-0.192	-0.165
in city-industry at start of period	(0.015)	(0.013)
Initial employment controls	Yes	Yes
Region x industry fixed effects	Yes	Yes
City growth covariates	Yes	
City fixed effects		Yes
	B. Measuring entrepreneurship through start-up employment share	
Log start-up share of employment	0.054	0.042
in city-industry at start of period	(0.009)	(0.009)
Initial employment controls	Yes	Yes
Region x industry fixed effects	Yes	Yes
City growth covariates	Yes	
City fixed effects		Yes

Notes: See Table 2. Estimations describe the OLS relationship between entrepreneurship and city-industry growth. Industries are defined at the two-digit level of the SIC system. Region x industry fixed effects use the nine census divisions. Initial employment controls are city-industry specific. City-industries must have 100 employees throughout the 1977-2002 period to be included in the sample, for 12,178 observations. Standard errors are clustered by the nine census divisions.

Table 5: Extensions to city-industry level estimations

	Mining, constr., & manufacturing	Trade, finance, & services	Colder cities Jan. temp <34	Warmer cities Jan. temp >34	1982-1992 period	1992-2002 period
	(1)	(2)	(3)	(4)	(5)	(6)
	A. Measuring entrepreneurship through average establishment size					
Log average establishment size	-0.291	-0.120	-0.158	-0.175	-0.104	-0.095
in city-industry at start of period	(0.035)	(0.015)	(0.024)	(0.023)	(0.014)	(0.005)
	B. Measuring entrepreneurship through start-up employment share					
Log start-up share of employment	0.055	0.039	0.036	0.049	0.027	0.019
in city-industry at start of period	(0.016)	(0.007)	(0.011)	(0.013)	(0.007)	(0.003)

Notes: See Table 4. All regressions include Initial employment controls, Region x industry fixed effects, and City fixed effects.

Table 6: Historical mining deposits and the development of industrial structures

	Log average establishment size in manuf. 1963	Log average employments in mining near city 1976-1980	Log average establishment size in city, 1982			Log start-up employment share in city 1982
			Total	Mining, constr., & manufacturing sectors	Trade, finance, & services sectors	
	(1)	(2)	(3)	(4)	(5)	(6)
			A. Log mineral and coal mines within 500 miles of city			
Log mineral and coal mines within 500 miles of city, 1900	0.213 (0.068)	1.163 (0.094)	0.075 (0.014)	0.142 (0.031)	0.042 (0.017)	-0.161 (0.044)
			B. Panel A including indicator variable for coal or iron ore being top mineral product of state			
Log mineral and coal mines within 500 miles of city, 1900	0.204 (0.067)	1.149 (0.095)	0.071 (0.014)	0.133 (0.034)	0.037 (0.015)	-0.154 (0.040)
(0,1) Coal or iron ore is the top mineral product of the state, 1928	0.126 (0.059)	0.187 (0.091)	0.062 (0.016)	0.116 (0.046)	0.060 (0.020)	-0.096 (0.022)
			C. Mineral and coal mines within distance rings of city (coefficients x100)			
Mineral and coal mines within 100 miles of city, 1900	0.085 (0.039)	0.328 (0.056)	0.026 (0.015)	0.065 (0.051)	0.000 (0.007)	-0.091 (0.042)
Mineral and coal mines 100-500 miles of city, 1900	0.039 (0.015)	0.198 (0.033)	0.011 (0.004)	0.020 (0.008)	0.009 (0.003)	-0.030 (0.010)

Notes: See Table 2. All regressions include Initial employment controls, Census division fixed effects, and City growth covariates. Appendix Table 2 provides descriptive statistics regarding mining counts. Coal or iron ore is the top mineral product in 1928 for AL, CO, IL, IN, KY, MD, MI, MN, ND, PA, TN, VA, WA, and WV.

Table 7a: Instrumental variable estimations at city level - average establishment size

	Log employment growth: Total	Log employment growth: Colder cities Jan. temp <34	Log employment growth: Warmer cities Jan. temp >34	Log payroll growth
	(1)	(2)	(3)	(4)
	A. Instrument: log count of mineral and coal mines within 500 miles, 1900			
Log average establishment size in city at start of period	-0.967	-1.975	-0.848	-1.027
	(0.367)	(1.547)	(0.688)	(0.446)
Exogeneity test p-value	0.461	0.308	0.773	0.385
First stage partial R squared	0.151	0.018	0.112	0.151
F test statistic in first stage	0.001	0.220	0.000	0.007
Maximum 2SLS relative bias	<10%	>25%	<10%	<10%
	B. Instruments: Panel A + (0,1) top product is coal or iron ore, 1928			
Log average establishment size in city at start of period	-0.930	-1.020	-0.717	-0.968
	(0.273)	(0.650)	(0.411)	(0.300)
Exogeneity test p-value	0.386	0.649	0.819	0.280
First stage partial R squared	0.186	0.049	0.157	0.186
F test statistic in first stage	0.001	0.001	0.002	0.001
Maximum 2SLS relative bias	<10%	>25%	<15%	<10%
Over-identification test p-value	0.700	0.211	0.546	0.636
	C. Instruments: Panel B + count of iron mines in 100 miles, 1900			
Log average establishment size in city at start of period	-0.878	-1.153	-0.751	-0.889
	(0.269)	(0.403)	(0.267)	(0.288)
Exogeneity test p-value	0.496	0.232	0.661	0.781
First stage partial R squared	0.193	0.112	0.204	0.193
F test statistic in first stage	0.000	0.002	0.000	0.000
Maximum 2SLS relative bias	<15%	>25%	<20%	<15%
Over-identification test p-value	0.357	0.456	0.819	0.254

Notes: See Tables 2 and 6. Outcome variables are indicated by column headers. Instruments are indicated by panel titles. All regressions include Initial employment controls, Census division fixed effects, and City growth covariates. Standard errors are clustered by the nine census divisions. The null hypothesis in exogeneity tests are that the instrumented regressors are exogenous. The maximum 2SLS relative bias reports the minimum bias that can specified and still reject the null hypothesis that the instruments are weak. This level is determined through the minimum eigenvalue statistic and Stock and Yogo's (2005) 2SLS size of nominal 5% Wald test. The over-identification test employs Basmann's test statistic.

Table 7b: Instrumental variable estimations at city level - start-up employment share

	Log employment growth			Log
	Total	Colder cities Jan. temp <34	Warmer cities Jan. temp >34	payroll growth
	(1)	(2)	(3)	(4)
	A. Instrument: log count of mineral and coal mines within 500 miles, 1900			
Log start-up share of employment in city at start of period	0.450	0.589	0.674	0.478
	(0.163)	(0.334)	(0.633)	(0.205)
Exogeneity test p-value	0.082	0.209	0.446	0.095
First stage partial R squared	0.114	0.028	0.032	0.114
F test statistic in first stage	0.007	0.047	0.046	0.007
Maximum 2SLS relative bias	<10%	>25%	>25%	<10%
	B. Instruments: Panel A + (0,1) top product is coal or iron ore, 1928			
Log start-up share of employment in city at start of period	0.456	0.533	0.687	0.476
	(0.132)	(0.238)	(0.607)	(0.159)
Exogeneity test p-value	0.058	0.233	0.428	0.056
First stage partial R squared	0.128	0.036	0.032	0.128
F test statistic in first stage	0.001	0.018	0.074	0.001
Maximum 2SLS relative bias	<15%	>25%	>25%	<15%
Over-identification test p-value	0.901	0.756	0.082	0.963
	C. Instruments: Panel B + count of iron mines in 100 miles, 1900			
Log start-up share of employment in city at start of period	0.352	0.671	0.353	0.343
	(0.119)	(0.217)	(0.139)	(0.130)
Exogeneity test p-value	0.197	0.086	0.192	0.229
First stage partial R squared	0.157	0.041	0.133	0.157
F test statistic in first stage	0.000	0.046	0.000	0.000
Maximum 2SLS relative bias	<15%	>25%	>25%	<15%
Over-identification test p-value	0.083	0.547	0.533	0.072

Notes: See Table 7a.

Table 8a: Extensions to city level IV estimations of employment growth

	Mining, constr., & manufacturing sectors	Trade, finance, & services sectors	Level of industry agglomeration: Low	Level of industry agglomeration: Medium	Level of industry agglomeration: High	High agglom. trade, finance, & services
	(1)	(2)	(3)	(4)	(5)	(6)
			A. Average establishment size, single IV			
Log average establishment size in city at start of period	-0.384	-0.753	-0.585	-0.569	-1.630	-1.054
	(0.225)	(0.325)	(0.334)	(0.210)	(0.342)	(0.300)
			B. Average establishment size, triple IV			
Log average establishment size in city at start of period	-0.481	-0.696	-0.502	-0.593	-1.778	-0.942
	(0.281)	(0.249)	(0.240)	(0.303)	(0.277)	(0.246)
			C. Start-up employment share, single IV			
Log start-up share of employment in city at start of period	0.179	0.351	0.272	0.265	0.758	0.491
	(0.093)	(0.132)	(0.145)	(0.082)	(0.174)	(0.114)
			D. Start-up employment share, triple IV			
Log start-up share of employment in city at start of period	0.186	0.260	0.179	0.236	0.761	0.344
	(0.102)	(0.110)	(0.110)	(0.108)	(0.135)	(0.111)

Notes: See Tables 7a and 7b. Outcome variables are log employment growth as indicated by column headers. All regressions include Initial employment controls, Census division fixed effects, and City growth covariates. The single instrument in Panels A and C is the log count of mineral and coal mines within 500 miles, 1900. The triple instruments in Panels B and D are the log count of mineral and coal mines within 500 miles, 1900; a (0,1) indicator variable for coal or iron ore being the top mineral product in the state, 1928; and the count of iron ore mines within 100 miles of the city, 1900.

Table 8b: Extensions to city level IV estimations of employment growth - warm cities

	Mining, constr., & manufacturing sectors	Trade, finance, & services sectors	Level of industry agglomeration			High agglom. trade, finance, & services
			Low	Medium	High	
	(1)	(2)	(3)	(4)	(5)	(6)
			A. Average establishment size, single IV			
Log average establishment size	-0.308	-0.704	-0.527	-0.914	-1.397	-0.942
in city at start of period	(0.428)	(0.633)	(0.597)	(0.400)	(0.722)	(0.619)
			B. Average establishment size, triple IV			
Log average establishment size	-0.605	-0.598	-0.270	-0.561	-1.981	-1.129
in city at start of period	(0.238)	(0.223)	(0.242)	(0.244)	(0.322)	(0.368)

Notes: See Table 8b. The sample is restricted to cities with mean January temperature greater than 34 degrees.

Table 8c: Extensions to city level IV estimations of employment growth - sector

	Single IV		Triple IV	
	Mining, constr., & manufacturing sectors	Trade, finance, & services sectors	Mining, constr., & manufacturing sectors	Trade, finance, & services sectors
	(1)	(2)	(4)	(4)
Log average establishment size in city at start of period in mining, constr., & manufacturing	-0.204 (0.120)		-0.234 (0.143)	
Log average establishment size in city at start of period in trade, finance, & services	.	-1.356 (0.692)		-1.166 (0.287)

Notes: See Table 8a. Average establishment size is separated by sector groupings.

App. Table 1: Basic entrepreneurship and city employment growth regressions by time period

	1982-2002			1982-1992			1992-2002		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	A. Measuring entrepreneurship through average establishment size								
Log average establishment size	-0.566	-0.598	-0.693	-0.385	-0.407	-0.432	-0.216	-0.280	-0.339
in city at start of period	(0.094)	(0.090)	(0.087)	(0.088)	(0.073)	(0.103)	(0.050)	(0.058)	(0.042)
Initial employment controls		Yes	Yes		Yes	Yes		Yes	Yes
Census division fixed effects		Yes	Yes		Yes	Yes		Yes	Yes
City growth covariates			Yes			Yes			Yes
	B. Measuring entrepreneurship through start-up employment share								
Log start-up share of employment	0.200	0.200	0.161	0.099	0.128	0.110	0.123	0.087	0.065
in city at start of period	(0.081)	(0.055)	(0.040)	(0.077)	(0.045)	(0.035)	(0.044)	(0.044)	(0.048)
Initial employment controls		Yes	Yes		Yes	Yes		Yes	Yes
Census division fixed effects		Yes	Yes		Yes	Yes		Yes	Yes
City growth covariates			Yes			Yes			Yes

Notes: See Table 2.

App. Table 2: Descriptive statistics on known mineral and coal mines, 1900

	Mean	Minimum	Maximum	Maximum City
Total mine counts discovered by 1900				
Total 0-100 miles	56	0	683	Hickory-Morganton-Lenoir, NC
Total 0-250 miles	270	0	1,022	Greensboro-Winston-Salem-High Point, NC
Total 0-500 miles	946	10	2,966	Salt Lake City-Ogden, UT
100-250 miles	214	0	990	Charleston, WV
250-500 miles	676	6	2,282	Provo-Orem, UT
Mines related to iron ore discovered by 1900				
Total 0-100 miles	13	0	232	Hickory-Morganton-Lenoir, NC
Total 0-250 miles	67	0	321	Roanoke, VA
Total 0-500 miles	244	2	630	Cleveland-Akron, OH
100-250 miles	54	0	314	Charleston, WV
250-500 miles	177	0	621	Toledo, OH
Mines not related to iron ore discovered by 1900				
Total 0-100 miles	43	0	451	Hickory-Morganton-Lenoir, NC
Total 0-250 miles	203	0	837	Reno, NV
Total 0-500 miles	701	6	2,629	Salt Lake City-Ogden, UT
100-250 miles	159	0	676	Charleston, WV
250-500 miles	499	4	2,030	Provo-Orem, UT

Notes: Descriptive statistics taken from USGS database.