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Abstract

We study the relative effect of venture capital and bank finance on large manufacturing firms in local U.S. markets. Theory predicts that with venture capital, the firm size distribution should become more stretched-out to the right, but it's ambiguous on the effect of banks on large firms. The empirical evidence suggests that while the average size of firms in the top bin of the firm size distribution has remained unaffected by banking sector developments, it has increased with venture capital investment. We argue that this is due to the emergence of new corporate giants rather than the growth of existing ones.

Keywords: venture capital, banking, firm size

JEL Classification: G24, J24, L11

Non-technical Summery

The U.S. economy has traditionally been characterized by the rapid emergence of corporate giants, and this process became increasingly visible during the second half of the 20th century. While in 1960 the turnover among industry leaders (those in the top 20% of their industry based on market value) was around 5%, it increased to 10% in 1980 and to 20% in 2000. In addition, of the 70 largest companies created between 1920 and 2000, a hefty 26 have been created after 1975. Importantly, this process has been procyclical in that a new leader is more likely to emerge during a boom than during a recession. In this paper, we investigate empirically the relative contribution to that process of the two most important financial developments in the U.S. over the same period – the bank deregulation of the 1970s and 1980s, and the emergence of a powerful venture capital (VC) industry since the 1960s.

We use data on firm size, bank deregulation, and venture capital investment between 1980 and 2001 for the 50 US states from the U.S. Census Bureau and the National Venture Capital Association. We first perform nonparametric difference-in-differences tests on whether average firm size in the top bin of the firm size distribution (100+ employees) increases with VC investment for VC-sensitive industries, and with bank deregulation for industries sensitive to bank finance. We next proceed with parametric tests which allow me to eliminate the effect of market and industry fixed effects. We also address the main problem with evaluating the real effects of VC identified by the literature, namely that both VC funding and the respective real effect (changes in the firm size distribution in this case) are endogenous to unobservables that vary by state and industry, like technological opportunities.

In all empirical tests, we consistently find a significant positive effect of venture capital finance, but not of bank deregulation, on the right skew of the firm size distribution. Specifically, a doubling of VC investment is associated with an increase in the average firm size of large firms by between 4 and 6 workers. These results hold regardless of the benchmark for sensitivity to VC finance we employ (actual use of VC funds, R&D-intensity, or intangible assets-intensity) and they survive when we account for errors in variables and look at different time periods and industrial classifications.

Finally, we ask the policy-relevant question, does this increase in the size and implied viability of industrial champions come from the emergence of new superstar companies, like Google and Microsoft, or from the growth of existing ones, like GM and IBM. If the latter is the case, in addition to increased size, one should also observe no changes in the relative share of large firms. We find the opposite: not only have firms with 100+ employees grown larger in states with higher VC investment, but also their relative share has increased. Therefore, venture capital investment affects the real economy rather through the creation and the subsequent coming-of-age of new firms. This has implications for the effect of finance on gradual vs. disruptive innovation – while "old" companies are better in the former, "new" companies excel in the latter, and so venture capital brings forth the latter's relative contribution to economic growth.

Our results have important policy implications for the development of a viable venture capital industry in Europe. The list of the world's 500 largest listed companies includes 26 US companies that were created after 1975 (out of a total of 168), and only 3 European companies created after 1975 (out of a total of 146). Our paper strongly implies that these differences could be explained by the explosion of VC in the U.S. in the last 30 years and by the larger dependence of Europe's corporate landscape on bank finance. In that respect, recent European developments aimed at liberalizing investment by institutional investors for diversification purposes, the emergence of well-functioning exit markets, and labor regulation aimed at promoting the mobility of skilled labor, can be instrumental in nurturing Europe’s superstar companies of tomorrow.

1 Introduction

The U.S. economy has traditionally been characterized by the rapid emergence of corporate giants, and this process became increasingly visible during the second half of the 20th century. While in 1960 the turnover among industry leaders (those in the top 20% of their industry based on market value) was around 5%, it increased to 10% in 1980 and to 20% in 2000. Importantly, this process has been procyclical in that a new leader is more likely to emerge during a boom than during a recession.[1] A look at the share of new corporate giants yields additional power to this observation: of the 70 largest companies created between 1920 and 2000, a hefty 26 have been created after 1975. For comparison, only 3 such companies emerged in Europe during that period.[2]

What is the contribution of finance to the emergence and growth of superstar companies? The second half of the 20th century saw two important developments in the U.S. financial sector - the branching and interstate bank deregulation that took place between the 1970s and the early 1990s, and the emergence of a large and sophisticated venture capital (VC) industry. And while economic research in recent years has focused intensely on the finance and growth nexus and on the mechanisms via which developments in the banking and VC sectors affect real economic activity[3], and especially on their effect on small firm entry and growth[4], the question of the relative effect of VC and bank finance on America's corporate leaders has been left largely unanswered. Does the fact that most of the large companies created since 1975 - like Microsoft, Cisco and Oracle - are in the high-tech sector imply that venture capital

[1] See Comin and Philippon (2005) for details.

[2] T. Philippon and N. Veron, "Financing Europe's Fast Movers," Bruegel Policy brief 2008/01.

[3] The idea to link finance and growth in a causal way traces back to Schumpeter (1912) and later Goldsmith (1969) and McKinnon (1973). The modern impetus to studying the nexus is usually attributed to King and Levine (1993a,b), and includes influential studies by Demirguc-Kunt and Maximovic (1998), Levine and Zervos (1998), Rajan and Zingales (1998), and Levine, Loyaza, and Beck (2000), among others. As for recent contibutions on the effects of bank deregulation and competition on growth, we cite Jayaratne and Strahan (1996), and Cetorelli and Strahan (2006), among others. Finally, some of the main studies on the real effects of venture capital include Kortum and Lerner (2000), Hellman and Puri (2000) and Gompers, Lerner and Scharfstein (2005).

[4] For the contribution of VC to new business incorporation, see Botazzi and Da Rin (2002), Mollica and Zingales (2008), and Popov and Roosenboom (2009), among others. For the effect of banks on small firm entry and growth, see, for example, Cetorelli and Strahan (2006), and Aghion, Fally, and Scarpetta (2007).

has contributed relatively more than banks to the emergence of today's corporate giants? Did increased competition among banks have an effect on large firms beyond allowing small young firms to challenge the large insiders? What specific characteristics of industries are affected by finance so that it eventually translates into real effects on the size of firms?

Our paper addresses these questions by studying the relative impact of bank and VC finance on a well-defined characteristic in product markets. Namely, we investigate the impact of banking deregulation and of the growth of VC investment on measures of industry structure in non-financial sectors, in particular, the average size of large firms. Essentially, we ask what has been the effect of finance on the right-hand tail of the firm size distribution[5], and whether banks and venture capitalists have been complements or substitutes in this development. To investigate the matter, we use data on U.S. local markets for banking, VC, and non-financial sectors during the 1980-2001 period. We find little evidence that developments in the U.S. banking sector have exerted a positive effect on the size of the largest firms, and the effect is only recorded for interstate deregulation. At the same time, we find strong evidence that venture capital investment has increased the average size of firms in the right-hand tail of the firm size distribution (namely, firms with 100+ employees). We find identical results when we look at the 100-500 employment bin in order to make sure that our results are not driven by M&A activity among very large firms. Our estimates remain virtually unchanged when we use the size of state and local pension funds as an instrument for venture capital investment,[6] and when we correct for the potential bias resulting from the fluctuating nature of the VC disbursement series. In addition, we find that not just the size, but the share of large firms has increased with VC at the expense of small firms. This combined evidence cannot be explained with the further growth of already existing large firms. Rather, we interpret our results in terms of the ability of finance, especially VC finance, to enable the emergence of successful firms in possession of large projects that over

[5] By doing so, we can directly focus on the effect of finance on large firms. For example, Kumar, Rajan, and Zingales (2001) use as a unit of observation median firm size. However, an increase in median firm size could be associated with an attrition of small firms rather than the growth of large ones.

[6] Since 1979, state and local pension funds are required to invest part of their funds in venture capital (Gompers and Lerner (1999)).

time grow to be the corporate giants of tomorrow.

The paper relates to two main lines of empirical literature. First, various researchers has sought to link general financial development to firm size. For example, Kumar, Rajan, and Zingales (2001) find that firms in sectors dependent on external finance tend to be larger in countries with more efficient financial systems. However, the general results on which firms benefit most from finance are ambiguous. On the one hand, Guiso, Sapienza, and Zingales (2004) find that small firms enjoy more growth benefits from regional financial development; Cetorelli and Strahan (2006) find a significant increase in the share of small firms following intrastate branching deregulation; and Beck, Demirguc-Kunt, Laeven, and Levine (2008) find that industries based on small firms for technological reasons enjoy faster growth with financial development. On the other hand, Petersen and Rajan (1994; 1995) provide evidence that financial liberalization has hurt small firms by weakening relationship finance[7]. Second, two distinct streams of research have linked banks and venture capital to firm growth. For example, Cetorelli (2002) shows that more bank concentration is associated with a delayed exit of large old firms; Beck, Demirguc-Kunt, and Maksimovic (2004) find that higher banking concentration favours large firms by erecting steeper financial constraints before small firms and new entrants; and Cetorelli and Strahan (2006) show that bank competition is associated with a smaller average firm size and a larger share of small firms.[8] On the VC side, among others, Hellman and Puri (2000) show that VC-backed firms hire more workers, controlling for firm age and industry, implying that VC is associated with larger firms on average, while Gompers, Lerner, and Scharfstein (2005) show that VC-backed firms tend to spawn more new firms, implying that VC allows small new firms to challenge established incumbents.[9] Our paper attempts to bridge these distinct strands of literature together.

[7] For an excellent review on the general determinants of the firm size distribution, beyond finance, see Cabral and Mata (2003).

[8] The last study is so far the only one to look at how banking sector developments affect the share of large firms, without, however, looking at the effect of such developments on their size.

[9] On an extensive early review of the role of banks and venture capital in the financial growth cycle of the firm, see Berger and Udell (1998).

Ours is the first study to compare the relative effects of venture capital and bank finance on the firm size distribution, in particular on the size of large firms. This is crucial as it goes to the heart of policies aimed at improving economic efficiency. For example, the bank deregulation of the 1970s and 1980s improved access to finance for small firms and enhanced product market competition. The same applies for venture capital and its ability to bring to the marketplace new firms in possession of disruptively innovative ideas. It has also been shown that product market competition has increased firm-level volatility and the turnover of industry leaders (Comin and Philippon (2005)), but we don't know what the effect of this process has been on the equilibrium size of the successful large firms. It is therefore essential to provide knowledge on whether it is indeed the superior ideas that quickly benefit from debt and equity finance to become full-blown corporate giants like Microsoft and Google. In addition, it is important to know whether this development is equally strong in "old" and in "new" industries. By observing the firm size distribution development at the industry level, we are able to answer the above question by distinguishing "old" industries from those at the forefront of technological progress.

The remainder of the paper is organized as follows. Section 2 describes the theoretical links between venture capital and bank finance, on the one hand, and firm size on the other hand. In Section 3, we discuss our identification strategy. Section 4 presents the data set and main variables used in the analysis. Section 5 reports the empirical results, and Section 6 concludes.

2 Banks, VC, and large firms: theoretical arguments

What is the effect of bank finance and of venture capital on firm size in non-financial industries? King and Levine (1993b) were the first to suggest a theoretical framework linking general financial development to the distribution of firm sizes. In particular, they argue that by improving the probability of successful innovation, financial development benefits the largest projects. This implies that a more efficient financial system should be able to see faster growth of firms in possession of valuable ideas, and so in practice financial development should make the distribution of firm sizes more stretched-out to the right. However, this is a general prediction which doesn't distinguish between debt and private equity finance. Cetorelli (2002) and Cetorelli and Strahan (2006) point out to the several counterveiling channels via which the best defined characteristic of banking markets - competition - affects product markets structure. Market power may reduce the effect of the informational opacity of the firm via the channel of long-term relationship building. For this reason, small firms may tend to thrive on local banking monopolies (Petersen and Rajan (1995)). This could allow them to successfully challenge large firms in the marketplace and prevent large firms from growing further. Market power may also reduce credit in general due to banks exploiting their monopoly position. This will result in less credit for everyone, inducing larger firms to invest less than is optimal and again prevent them from growing optimally. On the other hand, market power may be hurting small firms and favouring large incumbents. For instance, competition may induce banks to be more efficient and give them incentives to evaluate - via the use of various analytical credit scoring models - small opaque projects that wouldn't have received debt finance before. Also, the value of a bank's current lending relationship will depend on the future profitability of its borrowers. Consequently, the bank's incentive to support the profitability of its existing clients will restrict its willingness to expand credit to small firms and/or newcomers (Cestone and White (2003)). Finally, a concentrated banking system may support relationship lending and be detrimental to new business creation, favouring large firms (Perotti and Volpin (2004)). In this set-up, banking concentration is a form of a barrier to entry, allowing large firms to grow undisturbed.

Cetorelli and Strahan (2006) test these theories and find that the second strand of literature is the more plausible one given the empirical evidence from the U.S. branching and interstate deregulation. Their evidence suggests that the increased banking competition has resulted in an influx of entrants, driving average firm size down, and decreasing the share of large firms. However, they do not look at average size in the largest bin, and so it is entirely possible that over the period, bank finance has benefited both small firms by stimulating more of them to enter, and large firms by enabling large opaque projects to enter and subsequently grow into corporate giants.

Regarding VC, several recent papers have developed theoretical frameworks that allow to think of the differential effect of venture capital vs. bank finance. In principle, the difference between bank and VC finance is that venture capitalists screen, monitor intensively, and provide expertise[10]. Therefore, in comparison with banks, they are capable of taking on larger but riskier projects, and of further enhancing the value of the project. For example, in Landier (2003) an economy's entrepreneurs choose safe small projects backed by bank debt and low monitoring if the stigma associated with failure is high and risky large projects backed by venture capital finance if the stigma associated with failure is low. Ueda (2004) presents a model in which firms choose the type of finance based on the trade-off between technological expertise and the risk of expropriation. Her model predicts that VC-backed projects achieve faster growth, and that larger projects are financed by VC. Finally, Winton and Yerramilli (2008) develop a model of entrepreneurial choice of finance based on the trade-off between VC expertise and the higher return demanded by venture capitalist to compensate for the liquidity restrictions imposed by VC funds on their investors. Their model yields similar predictions in that in equilibrium, venture capitalists end up financing larger projects than banks. An empirical implication shared by all those models is that with VC is expected to result in the emergence of larger firms in equilibrium.[11] Our paper is a direct test of these bank vs. VC hypotheses.

3 Empirical model and identification strategy

The previous section implies that the theoretical arguments are ambiguous as to the effect of bank competition on the size of large firms. They either suffer after being subjected to more fierce competition from prospective newcomers, or they grow even bigger as their smaller

[10] See Kaplan and Stromberg (2001; 2002) for details.

[11] Lending empirical gravitas to this prediction, Kaplan and Stromberg (2002) find that venture capitalists invest a median of $4.5 million in their portfolio companies in each stage, which is significantly more than the median amount lent by banks to start-up firms.

competitors are weeded away by the destruction of soft information. As for VC finance, theory is relatively united in that VC should stimulate the emergence of larger projects relative to bank finance, and so we expect to see a bigger average size of large firms. The simplest empirical procedure that can be implemented to test those predictions is one which directly relates finance to firm size.

The standard difficulty with such an approach is that common factors affect both financial development and firm size and are unobservable from the point of view of the econometrician. Cetorelli and Strahan (2006) point out that small markets are usually characterized by fewer (and smaller) firms and by fewer banks (hence, more concentrated banking sectors), and so finding a positive correlation between the two would render no grounds for a causal interpretation. By the same token, venture capital has mostly thrived in dynamic local economies, characterized by advanced knowledge networks. Finding a positive association between VC and larger firms could simply pick the fact that both VC investment and fast-growing corporate giants are observed in markets inhabited by superior commercial ideas.

To address these issues which confound identification, we proceed to implement the idea initially put forth by Rajan and Zingales (1998) that finance plays a more important role for firms in industries that are more dependent on finance for technological reasons. Some of the natural characteristics of the industry that make some industries more dependent on one or another type of finance, are variations in the scale of projects, gestation period, the ratio of hard vs. soft information, the ratio of tangible vs. intangible assets, follow-up investments, etc. For example, a firm in an industry like "Tobacco" will be more likely to depend on external finance than a firm in an industry like "Electrical and electronic equipment". Analogically, an industry rich in intangible assets and poor in physical assets like "Instruments and related products" will be more dependent on VC finance than an industry like "Stone, clay, glass and concrete".

The basic idea then is to rank industries by their "natural" sensitivity to debt finance and VC finance, and use the industries which have low sensitivity to either type of finance as a control group in a standard difference-in-differences empirical model. Identification is achieved by measuring the differential effect of a) developments in the bank sector between industries that are sensitive to bank finance and those that are not; and of b) VC development between industries that are sensitive to VC finance and those that are not. Given the empirical predictions outlined above, we are ignorant about the differential effect of bank competition between the two treatment and the control group, while we expect higher volumes of VC finance to be translated into an increase in the average size of large firms for the control group.

We use the underlying data on firm size, venture capital investment, and bank sector deregulation to estimate the effects of venture capital investment and bank finance on firm size in a fixed-effects model, as follows:

$$\begin{aligned} Y_{ijt} = \ & \alpha \cdot Industry\ trend_{jt} + \beta \cdot Market\ trend_{it} + \gamma \cdot Employment\ share_{ijt} + \\ & + \delta \cdot VC\ sensitivity_j \cdot VC_{it} + \eta \cdot Bank\ sensitivity_j \cdot Banks_{it} + \varepsilon_{ijt} \end{aligned} \tag{1}$$

where Y_{ijt} is the log of average firm size in the top bin of the firm size distribution in state i in industry j during year t. The *Industry trend* variable is a matrix of industry-year indicator variables controlling for any industry-specific, time varying effects on industry structure. Analogically, the *Market trend* variable is a matrix of state-year indicator variables controlling for any market-specific, time-varying effects on industry structure. These fixed effects also account for convergence phenomena as in Barro and Sala-i-Martin (1992). Industry j's share of total manufacturing employment in state i during year t controls for the relative importance of a given sector in the market.[12] *VC* and *Banks* measure state-year characteristics of the banking sector (degree of competition) and VC market (VC investment). *VC sensitivity* and *Bank sensitivity* measure industry-specific sensitivity to VC

[12] Studies of cross-sector industrial growth consistently predict that sectors which have already grown fast in the past grow less in the future (see, for example, Rajan and Zingales (1998)) and have larger average firm size (see, for example, Cetorelli and Strahan (2006)). In addition, theories of the industry's lifecycle predict that sectors which are already relatively large should have lower rates of new business incorporation (see, for example, Klepper [1996]). Hence, the share variable included in the regression should capture the different propensity to entry and growth due to life-cycle specific reasons.

finance and bank finance, respectively.[13] Finally, ε is the idiosyncratic error.

As in Rajan and Zingales (1998) and Cetorelli and Strahan (2006), by including the two sets of fixed effects, we fully absorb the effect of any unobservable confounding factor that may be precluding identification. Thus we minimize the risk that our estimates are driven by reverse causality (for example, VC investment being driven by the demand of large firms) or by an omitted variable (for example, the arrival of technological opportunities being beneficial to VC financing in an entrepreneurial setting). Note that we are not able to identify the direct effect of VC and bank finance and industry sensitivity to VC and bank finance, as those are fully captured by the two sets of fixed effects. We thus only identify the effect of bank finance on bank-sensitive relative to bank-nonsensitive sectors, and of VC investment on VC-sensitive relative to VC-non sensitive industries. In all, we have a panel of 20 industries in 50 states over 1980-1997, or a maximum of 18,000 observations. In later tests we include data for 1998-2001. However, as it comes in NAICS 1997 classification code, we lose a number of industries in the matching to the 1987 SIC classification. We are left with a sample of 13 industries in 50 states over 1980-2001, or a total of 14,300 observations.

While parsimonious, the empirical model has a number of advantages. First, the fixed effects matrices control for time-variant differences in firm size due to unexplained factors that differ across states and industries. For example, commercial law may prevent firms from growing too big due to competition considerations, or corporate taxes and environmental regulations may be discouraging firms from reaching their optimal scale. The procedure also controls for the business cycle. Second, the panel data setting is ideal when testing theories that predict an effect over time of a change in the environment. As noted already, most of the bank deregulation events at the state level took place during the sample period. As for the VC industry, while it was not born during the sample period, the structural break in VC funding associated with the 1979 clarification of Employee Retirement Income Security Act (ERISA) by the Department of Labor is just outside it. Partially as a result from the

[13] We explain in detail the data and methodology used to construct these variables in the next Section.

1979 clarification of ERISA[14], between 1980-1983 and 1993-1997, VC investment increased 26 times in nominal terms (Table I) and 12 times in real terms, implying a large enough shift to estimate the model empirically.

4 Variables and data sources

We begin by constructing a panel data set of manufacturing establishments across U.S. states between 1980 and 2001. Data on establishments are available at a disaggregated industry level on an annual basis from the County Business Patterns, which is an annual survey by the Census Bureau.[15] The data provides the best opportunity to observe the industry structure in local U.S. markets over a long period of time. However, further disaggregation by industry code or geography creates substantial difficulties with missing values (Cetorelli and Strahan (2006)), and so we choose to focus on two-digit SIC codes in terms of industry disaggregation and on the state level in terms of geographic disaggregation. Given that the focus of the study is to test predictions about the evolution of the size of large firms, we use the original data to compute the average large firm size in each industry-state-year, defined as the total employment in the 100+ employment bin divided by the total number of establishments in the 100+ employment bin.[16] We construct this variable for each state-industry-year. The average establishment in the 100+ employment bin had 267 workers over the period. This reflects a decrease of 10 employees, from 272 during the 1980-83 period to 262 during the 1998-2001 period. The evolution of firm size in the 100-500 employment bin is virtually identical (Table I). The 100+ employment bin accounted for around 15% of all establishments. Finally, while the number of establishments and the number of firms is not perfectly correlated, the correlation over the period has been very close to 1 in recent

[14] See Gompers and Lerner (1999) for details.

[15] We exploit the same source of data on establishments as do Cetorelli and Strahan (2006), who focus on 1977-1994, but we extend the sample period. While banking deregulation across the U.S. was completed by the mid 1990s, we wish to capture as much of the development of the venture capital industry as possible. 2001 is the last year for which data is available in the County Business Patterns.

[16] For robustness purposes, in order to address the fact that too large firm may be the result of M&A rather than firm growth, we repeat most tests for the 100-500 employment bin only.

years: for example, in 2001, 94% of the U.S. firms (measured using IRS-issued Employer Identification Numbers) had a single establishment.[17] To the extent that it is mostly the large firms which are likely to operate more than one establishment, which could bias our results, it is important to note that this bias goes "in the right direction", i.e. against finding any results.

<< Table I >>

4.1 Sensitivity to VC and bank finance: constructing benchmarks

Our identification strategy hinges upon a difference-in-differences empirical model which enables us to study whether VC (bank) finance has a differentially larger effect on large firm size in industries that are naturally more sensitive to VC (bank) finance. For this exercise to work, it is crucial to construct benchmark measures of VC and bank finance sensitivity which are pure measures of financial need and so are not confounded by variations in the supply of VC (bank) finance. Approaching the two types of finance one at a time, the easiest proxy for VC sensitivity at the industry level is to rank the two-digit SIC industries by the relative share of total venture capital allocated across the U.S. economy over the 1980-2001 period. This is a relatively trivial exercise which requires the matching of the National Venture Capital Association (NVCA) industry classes to two-digit SIC industry classes, and then constructing an indicator variable with a value of 1 if the industry is in the top 50% of VC-target industries over the period.[18] This variable then represents the actual use of VC finance by all firms, by industry.

While this measure is intuitive and easy to construct, it is imperfect in one important way. Namely, up to 99% of all projects that apply for VC funding are rejected (Gompers and Lerner (1999)). Therefore, a variable which measures the *actual* allocation of VC finance reflects the preferences of venture capitalists and the availability of VC funds as much as it

[17] See the Bureau of Labor Statistics Business Emploment Dynamics for details.

[18] The top VC-receiving industries according to the NVCA yearbooks are: Software; Biotechnology; Medical devices and equipment; Telecommunications; Industrial/Energy; Media and entertainment; Semiconductors; Computers and peripherals. See Table II for their matching into two-digit SIC industries.

reflects the demand for such funds. Variations in VC preferences and supply will introduce measurement error into the actual use of VC finance, and the extent of that noise is likely to be greater for firms in industries that are VC-sensitive. Therefore, we turn to the original Rajan and Zingales (1998) idea of using the financing patterns of large mature Compustat firms as a benchmark for natural financial needs. The key identification mechanism is that large mature firms are not credit constrained, and hence their actual financing patterns are a fair representation of the industry's natural demand for finance. However, as VC finance usually comes in early stages of the life of the firm, it is meaningless to measure the actual use of VC funds by large mature firms. Instead, we proceed to construct proxies for industry characteristics which are close-to-perfect complements with the demand for VC finance.

The first such characteristic is R&D intensity. Given the comparative advantage of VC finance discussed in the introduction, VC is usually demanded by firms that have the potential for high growth and whose market product is based on the commercialization of science. Various researchers have found VC to be most in demand in industries like biotechnologies, information technologies, and communications, which are extremely R&D-intensive (Jeng and Wells (2000); Gompers and Lerner (2001)). Kortum and Lerner (2000) test empirically the hypothesis that VC finance and corporate R&D are complements in the production of innovation. While they argue that in theory, VC is demanded relatively more in an entrepreneurial firm set-up with disruptive innovation, while R&D is demanded relatively more in a corporate set-up with incremental innovation, they find strong evidence to the complementarity in the production of patents for most industries.

The second such characteristic is intangibles intensity. As pointed out by Gompers and Lerner (1999), firms that have the highest demand for VC funds are potentially in possession of a substantial amounts of intangible assets - like patents, licences, trademarks, etc. - which can be difficult to value and may be impossible to resell if the firm fails. A host of theoretical models have predicted that entrepreneurs finance through venture capital if they are short of physical collateral and rich in intangible assets (Holmstrom and Tirole (1997); Ueda (2004)). This prediction relates to the widely upheld empirical observation that collateral provision is an essential characteristic of bank loans, whereas it is not for venture capital financing.

We proceed by taking all Compustat firms between 1980 and 1997. We first exclude all firms that are young in the sense that they have gone public only recently (in the last 10 years) to make sure that we are not capturing the excessive appetite for funds exhibited during the early life of a public firm. Then, we sum across all years the ratio of research and development expenses over sales. We take the median industry value of that ratio and this value constitutes our benchmark for R&D intensity. Analogically, we sum across all years the ratio of intangible assets to net fixed assets, and take the median industry value of this ratio as a benchmark for intangibles intensity.

Finally, as our benchmark for sensitivity to bank finance, we take industry median value of the sum across years of total capital expenditures (Compustat item #128) minus cash flow from operations, i.e., revenues minus nondepreciation costs (Compustat item #110) plus decreases in inventories and accounts receivable plus increase in accounts payable. The benchmark is readily available from Cetorelli and Strahan (2006). While it is clear that this is not simply a measure of the industry's "natural" demand for bank debt, but also of dependence on other sources of external finance, like the corporate bonds market, Cetorelli and Strahan (2006) show that this benchmark is very highly correlated ($\rho = 0.51$) with actual use of bank finance by firms. This feature plus the the fact that it is not skewed by constraints on the supply side makes the benchmark a powerful instrument for sensitivity to bank finance.

<< Table II >>

Table II reports those benchmark measures for all two-digit SIC manufacturing industries. Looking across sectors, we find that the least R&D-intensive variables are "Tobacco manufacturing" and "Apparel and other textiles", while the most R&D-intensive industry is "Instruments and related products". The least intangibles-intensive industries are "Petroleum and coal products" and "Stone, clay, glass and concrete", while "Printing and publishing" and "Miscellaneous manufacturing" are by far the most intangibles-intensive ones. Our indicator variables for VC allocation is highly correlated with both our benchmark for R&D (0.57) and intangibles (0.34) intensity. Finally, our bank sensitivity measure ranges from -0.96 for "Leather and leather products" (least dependent on external finance) to 0.28 for "Chemicals and allied products" (most dependent on external finance). As noted by Cetorelli and Strahan (2006), in a difference-in-differences framework one wishes to emphasize the distinction between low-dependent (control group) and high-dependent (treatment group), and so we also use for robustness purposes indicator variables equal to 1 if the industry belongs to the top half of the distribution of the respective benchmark intensities.

4.2 VC investment and banking sector development

Next, we turn to the data on development in the VC and banking industry. As a proxy for the size of the VC industry in each state-year, we take data from the NVCA on VC investment at the state-year level, over 1980-2001, in millions of current dollars. For the purpose of the empirical exercise, we then convert that series into constant 1980 dollars using PPI series from the Bureau of Labor Statistics. Table III gives a detailed picture of the development in VC finance across states and over time between 1980 and 2001 (in current dollars), as well as of the deregulation events at the state level. The average real annual growth in per-state VC investment between 1980 and 1997 was 14.8%. The annual growth was naturally highest during the dot-com years: VC grew by an average of 26.7% per year between 1992 and 1997. In 1995 alone, VC investment grew by an average of 45%; the maximum annual increase was in Vermont in 1992 (294%). These large variations over time urge a refinement of the basic methodology which we discuss later.

<< Table III >>

Our main measure of banking sector development exploits policy innovations. Table III contains information on bank deregulation events across the U.S. states during the sample period. As is well known from Jayaratne and Strahan (1996) and Strahan and Cetorelli (2006), most states either prohibited branching altogether or limited it severely until the

1970s, when only 12 states allowed unrestricted state-wide branching. By 1994, however, the remaining 38 states also deregulated their restrictions on branching. In addition, in the early 1980s many states began to enter regional or national reciprocal arrangements whereby their banks could be bought by any state in the arrangement. Subsequently, in 1993 Montana became the last state to deregulate interstate banking. One unambiguous consequence of this regulation-driven development has been a positive effect on a range of economic phenomena, like real GSP growth (Jayaratne and Strahan (1996); Huang (2006)). For the purpose of our study, these events present us with an opportunity to test how the position of large firms was affected by those competition-enhancing events. We capture the effect of each type of deregulation by constructing an indicator variable equal to 1 in the years after a state permits branching by means of merger and acquisition within its borders, and another indicator variable equal to 1 in the years after a state permits interstate banking.

Our binary measures by definition are unable to capture how much the lifting of branching restrictions affected the size of the banking sector. For that reason, in robustness tests we also use data on total in-state and out-of-state assets held by holding companies operating in each state in each year, divided by total banking sector assets in each state-year. This is an attractive measure as it provides us with a continuous variable capturing the magnitude of the flows in banking capital.

5 Results

5.1 Nonparametric difference-in-differences estimates

As already explained in Section 3, our identification strategy hinges upon the estimation of the differential effects on the size of large establishments of developments in VC markets across VC-sensitive and VC-nonsensitive sectors, and in bank markets across bank-sensitive and bank-nonsensitive sectors. Table IV gives a simple non-parametric illustration of this strategy. In Panel A, we average the data over four groups: industries with high and low VC-sensitivity and states-years with high and low level of VC finance (where we take the top

25 states in terms of VC investment as a share of GSP over 1980-1997 to be those with high VC investment). In Panel B, we repeat the exercise for the case of banks by again averaging the data over four groups: industries with high and low bank-dependence and states-years where banking sectors were deregulated/regulated. The table implies that our estimates depend on the differential response of large firm size in different sectors. For the case of VC, a large establishment in a VC-sensitive industry has on average 4.5 employees more than a large establishment in a VC-nonsensitive industry in states with high ratio VC/GDP. On the other hand, large establishment size is on average lower by 6.9 employees for VC-sensitive industries in states with low ratio VC/GDP. Hence, the combined effect of an increase in VC investment is an increase of 11.4 employees on average (4.5-(-6.9)=11.4). However, we find the opposite results in Panel B. Namely, banking deregulation has decreased the difference in the size of large establishments in bank-sensitive vs. bank-nonsensitive industries by about 10 employees.

<< Table IV >>

Table IV thus presents a very useful illustration of why our identification strategy makes sense. Only focusing on the effect of VC and banking market developments on large firm size, one would conclude that both VC and bank deregulation have pushed the size of America's largest firms down[19]. However, large establishment size negatively correlates with VC and deregulation for reasons that go beyond finance itself. For example, in the case of VC, large markets like the Bay Area or the North-East are characterized by an abundance of educated entrepreneurs, whose entry in the market exerts competitive pressures on large firms, as well as by more dynamic VC industries. Table IV thus supports the need for a parametric estimation which would eliminate fixed industry and state effects, as well as trends at the level of those two units of observation. We then proceed in the next subsection with the parametric estimation displayed in equation (1).

[19] For instance, average large firm size is lower by 25 employees in states with high ratio VC/GDP (266 vs. 290.9).

5.2 Parametric results: venture capital, banks, and firm size in the largest employment bin

Table V presents the results of the main model, namely the regression results for the log of average size in the 100+ employment bin (Panel A). To counter the argument that these might be driven by M&As, which can hardly be linked to VC or bank finance, we repeat the estimations for the log of average size in the 100-500 employment bin (Panel B). We also advance our difference-in-differences strategy by noticing that we are essentially interested in the differential effect across finance-sensitive and finance-nonsensitive industries. Therefore, in the case of VC, we interact finance with both the level of R&D (intangibles) intensity, and with an indicator equal to 1 if the industry is in the top half of the distribution of R&D (intangible) intensities. Column 1 reports the interaction effect of the indicator of VC-sensitivity based on actual VC allocation with VC investment; in Columns 2 and 3 the interaction is based on R&D intensity (levels and indicator, respectively); and in Columns 4 and 5 on intangibles intensity (levels and indicator, respectively). In all cases, the banking interaction involves our measure of dependence on external finance and the deregulation dummies. Consistent with (1), we include a full set of industry-year and state-year dummies to capture all trends and fixed effects at the industry and state level. Those capture also the direct effect of VC investment, bank deregulation, and the industry characteristics of interest. In addition, to alleviate issues of heteroskedasticity (trends which are similar across states and/or industries), we cluster the standard errors by industry and state.

The results are strikingly consistent across different benchmarks for VC-sensitivity. Namely, with the exception of the R&D intensity indicator, all estimates point to an increase in the average number of workers employed by firms in the top bin of the distribution of firm sizes in VC-sensitive industries, following an increase in VC investment. While our procedure precludes us from identifying the level effect of VC on employment, our estimates imply that a doubling of VC investment is associated with as little as a 1.6% larger increase in average large firm size in VC-sensitive industries relative to VC-nonsensitive ones, corresponding to a relative average increase of about 4 employees, for our main measure of VC sensitivity, the indicator one. In the case of level R&D and intangibles intensity, these are continuous variables so the interpretation is somewhat more tricky. Namely, one can only report the relative effect of higher VC investment when comparing industries at the 75th percentile and industries at the 25th percentile of R&D (intangibles) intensity. So for example, the respective values for intangibles intensity are 0.9 (Instruments and related products) and 0.21 (Textile mills products). Therefore, our coefficients imply that a doubling of VC investment is associated with a relatively bigger increase by 2%, or about 6 workers. When we instead employ the indicator variable, which allows you to calculate the relative effect directly, we find an increase of about 2 workers. We find broadly the same effects when we look at the 100-500 bin (Panel B), alleviating concerns that our results may be driven by a more dynamic M&A activity in states with larger VC investment.[20]

<< Table V >>

The effect of the banking interaction term is equally consistent in that although we find a positive effect of deregulation on the size of large firms, in no specification is this effect statistically significant. This result appears to be consistent with Cetorelli and Strahan (2006) who find that banking deregulation decreases average firm size and the share of large firms, and attribute this phenomenon to increased rates of new business incorporation. One might have expected the average size of large firms to have gone down with increased competition from small competitors, but this is not the case. Putting all the information together, we conclude that the increased entry of small firms due to banking deregulation has had no effect on the corporate leaders: it has neither reduced their size via the forces of increased competition, nor has it lead to the emergence of stronger corporate leaders by forcing banks to evaluate risky but large projects that they didn't approach before.[21]

[20] In unreported regressions, we also drop from the sample California and Massachusetts, which at any given year account for up to 60% of total VC investment in the U.S. The results are unaffected by this procedure.

[21] In unreported regressions (results available upon request), we obtain similar results when we use a continuous measure of banking sector development, namely in-state and out-of-state assets holdings by

5.3 Addressing the endogeneity of VC

While our model allows us to eliminate the effect of time-variant unobservables at the state and sector level, the possibility still remains that our results are biased by unobservables at the state-industry level. For example, markets that are away from knowledge networks may have little supply of ideas attractive to VC investors. Such markets will tend to rely more on low-tech industries and have small volumes of VC finance. Finding a positive association between VC investment and larger firms across states and industries could simply be picking up this market characteristic.

In order to address this endogeneity concern, we need to use a variable that is correlated with VC finance but uncorrelated with unobservable state-industry shocks. In other words, we aim to pursue identification by exploiting exogenous variations across states in the supply of VC finance. One immediate supply-shifter suggested by the literature is the size of state and local pension funds (Kortum and Lerner (2000)). As pointed out in Gompers and Lerner (1999), the 1979 clarification of the ERISA by the U.S. Department of Labor led to a five-fold increase in VC investment in the next two decades. State law also requires pension funds to invest in risk capital markets for diversification purposes. How much they would invest in reality is of course a function of their size. Therefore, the amount of total assets of state and local pension funds is an ideal instrument as it is correlated with VC finance but not with technological opportunities. We collect data on the size of assets of state and local pension funds from the State and Local Government Employee-Retirement Systems survey of the U.S. Business Census. The survey covers the period 1992-2007, so unfortunately we lose the data on establishment size and VC associated with the 1980-1991 period. Some idea of the development of state pension funds over time was given in Table I.

The results from the first-stage regression are reported in Table VI. The size of state and local pension funds indeed is strongly correlated with VC investment at the state level. A doubling of the assets of the two types of funds leads to an increase in VC investment by

banks. The results also stay unchanged throughout when we replace the measure of bank dependence with a dummy equal to 1 if our original measure of bank dependence is in the top half of the distribution of industry bank dependencies.

3.4%. The regression, which includes state and year fixed effects, explains about 90% of the variation in VC investment across states and over time.

<< Table VI >>

The estimates from the second stage imply that more VC investment continues to be associated with a statistically significant increase in the average size of large firms in VC-sensitive industries even when the endogenous element of the supply of VC funds has been extracted. The magnitude of the coefficients is also somewhat higher for the 100-500 size bin, however, this is in large part because of the decrease in sample size relative to the OLS regressions.

5.4 Errors-in-variables in the VC series

Our final concern with the analysis so far is errors-in-variables. The problem is linked to the nature of VC investment. As pointed out by Kortum and Lerner (2000), the VC disbursements series tends to fluctuate a lot from year to year, partly because a single financing round may be providing funds to be spent over 2-3 years. Thus, the venture funding measure is prone to an errors-in-variables problem that might lead to downwardly biased coefficients. A natural solution is to aggregate all variables in periods longer than 1 year in order to eliminate transitory fluctuations and the effect of staging.

In order to circumvent the potential bias stemming from this problem, we adopt a version of Kortum and Lerner's (2000) proposed technique, namely computing averages of the logs of each variable over a several-year period. The new series results from aggregation into 3-year intervals (1980-1982, 1983-1985, 1986-1988, 1989-1991, 1992-1994, 1995-1997). Then we repeat the estimation procedure from before on the aggregated data. While this strategy allows to eliminate the fluctuations of the VC disbursement series, it comes at the expense of the assumption that any relevant market and sector trends only work their way into the data in 3-year periods rather than annually.

<< Table VII >>

The results of these regressions are reported in Table VII. We run both OLS and IV regressions to make sure that our identification strategy eliminates the combined bias resulting from omitted market and sector time variant unobservables and from the endogeneity of VC investment. The coefficients in the OLS regressions are smaller but close to the ones reported in Table V, alleviating our concerns about the errors-in-variables problem. However, the coefficients from the IV regressions are not statistically significant any more. Albeit worrying, this could in part be due to the fact that in the IV regressions, the sample has been reduced to two periods only (1992-1995 and 1996-1998).

5.5 Adding the period 1998-2001

As was just pointed out, the fact that there are only 6 years in the IV panel regressions is somewhat unfortunate. The IV estimator is consistent but biased and so an as-large-as-possible sample in the first stage regression is always desirable. In addition, we are missing the most important years of the dot-com bubble when VC-backed firms like Oracle, Yahoo and Amazon (to name just a few) became the large companies they are today. Data on establishment size for 1998-2001 is readily available from the County Business Patterns. However, it follows a NAICS 1997 classification, meaning that a number of industries cannot be matched to the SIC 1987 classification followed by the data for 1980-1997 period. Thus the increase in the time variation from adding 4 more years of data on establishment size and VC comes at the expense of a decrease in the sector variation, and this was the reason for the exclusion of the 1998-2001 period in the analysis so far. Now we add those years to exploit the increased sample size in the first stage of the IV regression and complement the analysis so far with information about the peak years of the dot-com bubble.

In Table VIII we report the estimates from the OLS and the IV regressions. This time we work with a 50-state 22-year 13-industry panel.[22] Thus we go from a maximum of 18,000

[22] The excluded SIC-level industries are Textile mills products (22), Apparel and other textiles (23), Industrial machinery and equipment (35), Electrical and electronic equipment(36), Instruments and related products (38), and Miscellaneous manufacturing (39). In addition, Food and kindred products (20) and Tobacco manufacturing (21) are merged into one industry to be matched to NAICS industries Foods manufacturing (311) and Beverages and tobacco product manufacturing (312).

to a maximum of 14,300 observations in the OLS regressions, but because of the addition of the years 1998-2001, we go from a maximum of 6,000 to a maximum of 6,500 observations in the IV regressions. The results from both OLS and IV confirm that venture capital has increased average employment in the class of large firms even when the dot-com years are included and the potential small-sample bias in the 2SLS procedure is addressed. However, in addition to that, we finally record some evidence that banking sector competition - in particular, interstate deregulation - has also increased the size of the largest firms. This finding is consistent with the hypothesis that large firms may benefit from better funding conditions induced by competition from the outside, or that such firm may have emerged as a result from competitive pressures on banks to start evaluating large but opaque and risky projects. However, it is unclear whether it is driven by the addition of 4 more years (that is, allowing for the effect of bank deregulation to be slower), or by the reorganization of the industry classification.

<< Table VIII >>

5.6 VC and the mechanisms of large firm growth

Our results so far imply that while developments in the U.S. banking sector have had little effect on large firms, venture capital has bolstered the size of superstar companies. But why has the average size of large firms increased following the expansion of the U.S. venture capital industry? Is it because existing large firms have grown further, or is it because venture capital has enabled young/small firms to grow into the new corporate giants? Our evidence so far is unable to answer these questions, and so we now turn our attention to examining the effect of VC on the whole firm size distribution. In particular, we know that VC has been beneficial for new business creation (Gompers, Lerner, and Scharfstein (2005); Mollica and Zingales (2008); Popov and Roosenboom (2009)). If VC has been associated with entry of small firms and growth of large existing ones, we should see the share of small firms increase at the expense of the share of large firms. If VC has enabled new entrants to quickly grow and challenge the existing giants, we should see the share of large firms increase as large projects reach their optimal scale thanks to venture capital finance.

To empirically address these conflicting hypotheses, we look at the effect of venture capital on the share of establishments in different bins of the employment-size distribution (Table IX). We divide the firm size distribution in four segments: the share of establishments with less than 100 employees, the share of establishments with between 100 and 250 employees, the share of establishments with between 250 and 500 employees, and the share of establishments with more than 500 employees. Then, we regress each share on the interaction between the log of VC investment in each state in each year and the VC sensitivity of the industry.[23] As before, we control for the relative importance of each sector by including the share of total employment in each size bin. Panel A reports the results from an OLS regression of industry shares on venture capital. To mitigate the possibility of heteroskedasticity, as in Cetorelli and Strahan (2006), in Panel B we transform the respective proportions using a logit transformation, and so the dependent variable now is $\log\left(\frac{Share_{ijt}}{1-Share_{ijt}}\right)$, where $Share_{ijt}$ is the share of establishments in a particular size bin in state i in industry j during year t.

<< Table IX >>

The results reported in both panels of Table IX are consistent with the hypothesis that venture capital has enabled the entry and/or growth of large projects. That is, the firm size distribution shifts to the right following increased VC investment. Our regressions provide clear evidence that the share of larger firms (>100 employees) has decreased at the expense of firms with less than 100 employees. Numerically, doubling VC investment has decreased the share of small firms by 0.8%, while, for example, it has increased the share of firms with 250-500 employees by 0.2%. We confirm these result in the logit procedure in Panel B, which gives us confidence that the results are not driven by heteroskedasticity. While the economic significance of these results is not so dramatic, we can safely reject the hypothesis that VC has been beneficial for small firms in the sense of only enabling them to enter,

[23] Given the identical results we record across our three measures of VC intensity, we confine ourselves to the indicator measure of VC receiving industries. See Table II for details.

and beneficial to large firms in the sense of enabling already existing ones to grow. Our evidence rather supports the alternative hypothesis, namely that VC has been beneficial to larger projects in the sense of enabling them to either jump bins or enter and relatively quickly become large firms. This contrasts with the result on bank deregulation in Cetorelli and Strahan (2006) who show that the share of large firms has either decreased or stayed unchanged (depending on how "large firm" is defined) following competitive developments in the U.S. banking sector. While they argue that financial markets should have little effect on large establishments which are likely to be part of firms with access to nationwide securities markets, we find that in a dynamic set-up in which the industry leaders frequently change, finance affects both the equilibrium size and share of large firms in the economy. Thus, we find support for the competition explanation of the industry leadership volatility recorded in Comin and Philippon (2005) and for the fact that it is relatively larger during economic booms.

6 Conclusion

In this paper, we set out to investigate the relative contribution of VC and bank finance to the growth of the large U.S. firms. Empirically, we study the effect of bank deregulation and VC finance on the average size of firms in the top bin of the firm size distribution in U.S. local markets. We employ in the process an identification strategy which allows us to evaluate differential responses, eliminate the effect of unobservables, and address endogeneity problems. We find that in most specifications, bank competition and the size of credit markets has no effect on the size of the largest firms, although we find a positive effect of interstate deregulation once we extend our sample period to 2001. However, in all specifications employed we find a strong positive effect of venture capital finance on the average size of firms in the right-hand tail of the firm size distribution. We find no evidence that this effect is driven by the two states that have been responsible for the bulk of the VC finance in the past two decades, California and Massachusetts. Our tests also exclude the possibility that the results we find are driven by unobservable market or industry trends or by M&A activity. The effect remains significantly positive when we use the size of local and state pension funds as an instrument to correct for the endogeneity of VC finance, suggesting a causal link between VC and the average size of large firms. We also find that not only the size, but the share of large firms in VC-sensitive industries has increased with venture capital investment. We argue that these results are broadly consistent with theoretical models of the choice between bank and VC finance, as well as weakly supportive of models which predict an overall beneficial effect of banking development and competition on large firms. Given the full extent of our evidence and the fact that large existing firms have already access to financial resources in the commercial paper, corporate bond, and equity markets, we interpret our results in terms of the ability of finance, especially VC finance, to enable the emergence of successful firms in possession of large projects that over time grow to be the corporate giants of tomorrow.

These findings suggest a number of interesting policy implications. For example, one concern associated with competition-stimulating policies (among which banking deregulation undoubtedly belongs) has always been that too much competition could reduce the size and scale of the industry leaders, weakening the competitive position of the U.S. in the world economy. We find such concerns to be unfounded. The picture our results paint is one in which increased competitive pressure by small firms has by no means been associated with a decrease in the size and, by extension, international competitive position of the corporate leaders. We find even stronger support for the development of a VC industry: while the explosion of VC investment in the last 30 years has undoubtedly resulted in more competition in most markets, by no means has it hurt the large industry leaders. On the contrary, we argue that since 1980, VC has been associated with the emergence of even larger and, potentially, healthier industry leaders, especially so in industries which are at the forefront of today's economy. In addition, it is highly likely that not only have companies benefiting from VC finance become more larger and more viable, but also incumbent companies have been forced to improve their efficiency. In that sense, VC finance may have welfare implications which go beyond the scope of this paper.

The paper leaves a number of important questions unanswered. To name just one, large differences in firm size exist not just across US states, but across economic areas. As mentioned in the introduction, the list of the world's 500 largest listed companies includes 26 U.S. companies that were created after 1975 (out of a total of 168), and only 3 European companies created after 1975 (out of a total of 146). Can these differences be explained by the explosion of VC in the U.S. in the last 30 years and by the larger dependence of Europe's corporate landscape on bank finance? While our results strongly suggest that finance can indeed affect firm size, questions that remain unanswered grant further exciting investigations.

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Table I
Summary Statistics

Data on average firm size in the 100+ and 100-500 employment bins come from the County Business Patterns, 1977-2001. The unit of observation for firms size is the state-industry-year. Data on pension funds assets come from the US Census Bureau, 1992-1997. Data on VC investment comes from the National Venture Capital Association, 1980-2001. Monetary variables are in current dollars, in the empirical exercises all monetary variables are deflated using PPI series from the Bureau of Labor Statitics.

Period	Variable	mean	median	sd	min	max
1980-1983	Average firm size, 100+	271.8	265.1	44.4	83.7	445.4
	Average firm size, 100-500	210.4	207.0	25.5	99.1	319.7
	VC investment (in mil. US$)	45.4	10.7	204.2	0	1,412.2
	Pension assets (in mil. US$)	--				
1984-1988	Average firm size, 100+	265.9	259.3	44.5	177.3	483.6
	Average firm size, 100-500	207.4	204.4	23.8	155.0	303.7
	VC investment (in mil. US$)	75.5	21.0	201.5	0	1,412.1
	Pension assets (in mil. US$)	--				
1989-1992	Average firm size, 100+	267.6	261.4	44.8	184.8	460.5
	Average firm size, 100-500	207.1	204.7	23.9	96.7	300.8
	VC investment (in mil. US$)	77.3	24.2	201.5	0	1,416,1
	Pension assets (in mil. US$)	18,368.7	10,294.8	29,355.6	7.1	168,062.9
1993-1997	Average firm size, 100+	269.0	262.8	45.8	176.8	483.0
	Average firm size, 100-500	208.5	205.8	24.2	99.3	307.5
	VC investment (in mil. US$)	202.6	50.0	593.9	0	6,040.3
	Pension assets (in mil. US$)	26,310.9	13,296.5	39,934.0	567.2	291,106.7
1998-2001	Average firm size, 100+	261.6	256.4	47.6	151.7	435.1
	Average firm size, 100-500	202.1	201.5	24.2	94.7	325.3
	VC investment (in mil. US$)	1,188.8	203.4	3,962.3	0	43,137.1
	Pension assets (in mil. US$)	42,124.8	20,884.2	62,547.2	1,997.3	387,533.2
Total	Average firm size, 100+	267.3	261.5	45.4	83.7	483.57
	Average firm size, 100-500	207.2	204.6	24.8	94.7	325.3
	VC investment (in mil. US$)	331.5	31.2	1,884.5	0	43,137.1
	Pension assets (in mil. US$)	31,775.4	15,268.9	50,138.1	7.1	387,533.2

Table II
Industry Sensitivities to VC and Bank Finance for Manufacturing Sectors

The indicator variable equal to 1 if the industry is in the top half of VC receiving industries is constructed after matching the SIC 1987 classification to the NVCA industrial classification. The top industries receiving VC funds over the 1980-2000 period according to the NVCA are: Software; Biotechnology; Medical devices and equipment; Telecommunications; Industrial/Energy; Media and entertainment; Semiconductors; Computers and peripherals. R&D intensity equals the industry-level median of the ratio of research and development expenses to sales for mature Compustat firms in the same industry over the period 1980-97. Intangibles intensity equals the industry-level median of the ratio of intangible assets to net fixed assets for mature Compustat firms in the same industry over the period 1980-97. Bank sensitivity is the proportion of capital expenditures financed with external funds for mature Compustat firms over the period 1980-1997. Mature firms are those that have been on Compustat for 10 years or more.

Two-Digit SIC 1987 Industry Sector	Indicator=1 if in Top Half of VC Receiving Industries	R&D Intensity for Mature Compustat Firms	Intangibles Intensity for Mature Compustat Firms	Bank Sensitivity for Mature Compustat Firms
20. Food and kindred products	1	0.068	0.75	-0.24
21. Tobacco manufacturing	0	0.000	0.49	-0.92
22. Textile mills products	0	0.011	0.21	0.10
23. Apparel and other textiles	0	0.000	0.53	-0.61
24. Lumber and wood products	0	0.007	1.20	0.04
25. Furniture and fixtures	0	0.014	0.49	-0.23
26. Paper and allied products	0	0.013	0.20	0.06
27. Printing and publishing	1	0.012	4.54	-0.07
28. Chemicals and allied products	1	0.052	0.96	0.28
29. Petroleum and coal products	1	0.007	0.02	0.09
30. Rubber and plastic products	0	0.005	0.46	0.04
31. Leather and leather products	0	0.008	0.33	-0.96
32. Stone, clay, glass and concrete	0	0.012	0.05	-0.20
33. Primary metal industries	1	0.014	0.11	0.03
34. Fabricated metal products	1	0.011	0.31	-0.24
35. Industrial machinery and equipment	1	0.022	0.25	0.01
36. Electrical and electronic equipment	1	0.067	0.77	0.22
37. Transportation equipment	0	0.013	0.24	0.01
38. Instruments and related products	1	0.071	0.90	-0.04
39. Miscellaneous manufacturing	1	0.014	2.29	-0.20
Median	--	0.012	0.475	-0.02
Correlation between Indicator and R&D intensity	0.57			
Correlation between Indicator and Intangibles intensity		0.34		

Table III
VC Investment and Bank Deregulation

Data on VC investment come from the NVCA, and is in millions of current dollars. A value of 0.0 implies that less than 0.5 mln. $ were invested in VC in that year. The bank deregulation dates are from Amel (1993).

	Average Annual Venture Capital Investment					Bank Deregulation	
State	1980-83	1984-88	1989-92	1993-97	1998-2001	Branching	Interstate
Alabama	3.7	12.6	5.0	54.4	123.8	1981	1987
Alaska	4.0	0.0	0.0	0.0	4.0	< 1980	1982
Arizona	20.0	32.4	35.5	85.2	334.5	< 1980	1986
Arkansas	0.0	2.0	10.0	11.3	11.0	1994	1989
California	739.0	1,272.8	1,235.8	3,299.4	22,718.8	< 1980	1987
Colorado	46.5	96.8	109.0	273.6	2,016.3	1991	1988
Connecticut	22.0	87.8	95.8	136.2	830.5	< 1980	1983
Delaware	1.0	3.0	5.0	6.4	105.7	< 1980	1988
Florida	26.3	42.4	40.8	281.6	1,490.5	1988	1985
Georgia	20.5	71.6	71.3	207.2	1,210.3	1983	1985
Hawaii	0.0	0.0	0.0	10.5	63.3	1986	1994
Idaho	8.0	0.0	5.0	8.0	17.3	< 1980	1985
Illinois	26.0	45.0	81.3	235.8	1,261.5	1988	1986
Indiana	5.0	14.2	9.7	28.2	102.3	1989	1986
Iowa	3.7	3.6	2.0	16.0	15.0	1994	1991
Kansas	1.0	2.8	8.7	9.8	86.3	1987	1992
Kentucky	1.7	3.8	6.3	26.0	86.3	1990	1984
Louisiana	11.3	3.6	3.0	15.6	138.8	1988	1987
Maine	2.0	12.2	8.7	4.0	65.8	< 1980	< 1980
Maryland	18.0	35.0	46.5	105.0	964.5	< 1980	1985
Massachusetts	220.3	403.4	321.0	784.0	5,533.3	1984	1983
Michigan	22.8	43.4	16.8	67.4	216.3	1987	1986
Minnesota	27.0	34.2	47.8	140.8	626.3	1993	1986
Mississippi	2.0	2.0	6.3	9.0	72.3	1986	1988
Missouri	3.3	6.8	20.0	58.4	401.5	1990	1986
Montana	0.0	1.7	1.0	0.0	19.3	1990	1993
Nebraska	1.0	1.0	0.0	11.2	56.3	1985	1990
Nevada	1.0	1.5	6.0	3.5	26.5	< 1980	1985
New Hampshire	5.8	15.4	20.0	34.6	348.8	1987	1987
New Jersey	35.8	103.8	99.5	281.6	1,555.5	< 1980	1986
New Mexico	1.5	9.4	3.0	17.7	13.8	1991	1989
New York	51.0	92.8	97.5	330.6	3,416.8	< 1980	1982
North Carolina	14.8	16.6	25.3	148.2	883.0	< 1980	1985
North Dakota	0.0	7.5	0.0	5.5	2.8	1987	1991
Ohio	15.5	39.0	30.3	111.4	507.5	< 1980	1985
Oklahoma	8.3	6.4	4.7	19.3	62.8	1988	1987
Oregon	23.3	68.8	40.3	60.8	408.3	1985	1986
Pennsylvania	31.8	64.6	92.8	301.4	1,494.3	1982	1986
Rhode Island	4.0	10.2	13.0	8.7	62.8	< 1980	1984
South Carolina	0.0	8.3	9.3	46.8	204.5	< 1980	1985
South Dakota	1.0	1.0	0.0	0.0	1.0	< 1980	1983
Tennessee	8.5	48.4	36.3	98.8	159.5	1985	1985
Texas	117.5	225.2	173.3	472.0	3,377.5	1988	1987
Utah	7.5	12.2	8.0	43.5	352.3	1981	1984
Vermont	1.5	5.3	8.5	5.5	19.7	< 1980	1988
Virginia	17.3	43.0	33.3	243.4	1,530.0	< 1980	1985
Washington	24.3	53.4	80.0	281.8	1,679.8	1985	1987
West Virginia	3.5	2.0	3.0	24.0	2.7	1987	1988
Wisconsin	5.0	11.6	13.0	24.8	113.5	1990	1987
Wyoming	2.0	2.0	0.0	2.0	0.0	1988	1987

Table IV
Average Large Establishment Size for States with High vs. Low VC Investment and for States with Deregulated vs. Regulated Banking Markets

The table reports a difference-in-differences estimate from a Mann-Whitney two-sided test of the effect on an average establishment in the 100+ employment bin of moving from one industry/market to the other. States with high VC/GDP are those which are in the top half of the VC/GDP distribution (VC/GDP>0.14), states with low VC/GDP are those which are in the bottom half of the distribution. VC-sensitive industries are those in the top half of VC-receiving industries distribution as reported by the NVCA. Deregulated states are states in which either branching or interstate banking has been deregulated. Bank-sensitive industries are industries with above-median need for external finance. See Table II for the underlying data on VC and bank sensitivity. *** denotes significance at the 1% level, and ** denotes significance at the 5% level, based on a simple *t*-test.

Panel A

	States with high VC/GDP	States with low VC/GDP	Difference
VC-sensitive industries	268.3	287.3	-10.4
VC-nonsensitive industries	263.8	294.4	-22.5
Difference-in-differences	4.5***	-6.9***	11.4***

Panel B

	States with deregulated banking markets	States with regulated banking markets	Difference
Bank-sensitive industries	280.2	289.6	-9.4
Bank-nonsensitive industries	261.6	261.1	0.5
Difference-in-differences	18.6***	28.5***	-9.9**

Table V
Venture Capital, Banks, and Average Large Firm Employment Size

The table reports estimates of the percentage change in the average size of business firms in the top bin of the size distribution as a result of VC finance. Each column reports statistics from a fixed effects regression, where the dependent variable is the log of average enterprise employment size in the 100+ bin (Panel A), and the log of average enterprise employment size in the 100-500 bin (Panel B). The terms of interaction are based on VC allocation by industry, on R&D intensity for mature Compustat firms, and on intangibles intensity for mature Compustat firms, for VC interactions, and on the measure of sensitivity to bank finance from Cetorelli and Strahan (2006), for bank deregulation interactions (see Table II for details). For R&D and intangibles intensity, we use in the interaction term both the level value (Columns labeled "Level") and an indicator equal to 1 if the industry is in the top 50% of the distribution of R&D and intangibles intensities, respectively (Columns labeled "Indicator"). Data on establishments are from the County Business Patterns, 1977-1997. Data withheld for confidentiality purposes are reported as "0" in the original file, and are consequently treated as missing observations. The VC series comes from the National Venture Capital Association (NVCA), 1980-2001, and is deflated into constant 1980 dollars. The bank deregulation variables are dummies equal to 1 in the year after the lifting of intrastate branching restrictions and on; data from Amel (1993). The analysis is performed on a panel covering the period 1980-1997. Industry share of employment equals the total employment in a given industry-state-year divided by the total employment in the corresponding state-year. White (1980) standard errors appear below each coefficient in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Panel A. Log average firm size in 100+ employment bin

	VC sensitivity measure				
	Indicator = 1 if Industry is in Top 50% of Industries Receiving VC Funds	R&D Intensity for Mature Compustat Firms		Intangibles Intensity for Mature Compustat Firms	
		Level	Indicator	Level	Indicator
Log VC × VC sensitivity	0.016 (0.002)***	0.073 (0.044)*	-0.001 (0.003)	0.005 (0.001)***	0.005 (0.002)***
Post-branching × bank sensitivity	0.012 (0.021)	0.004 (0.009)	0.004 (0.009)	0.006 (0.009)	0.006 (0.009)
Post-interstate × bank sensitivity	0.015 (0.015)	0.014 (0.016)	0.014 (0.016)	0.015 (0.016)	0.015 (0.016)
Industry share of employment	0.165 (0.044)***	0.202 (0.044)***	0.211 (0.044)***	0.203 (0.044)***	0.209 (0.044)***
Observations	4,758	4,758	4,758	4,758	4,758
Fixed effects	State × Year Industry × Year				
R^2	0.62	0.62	0.62	0.62	0.62

Panel B. Log average firm size in 100-500 employment bin

	VC sensitivity measure				
	Indicator = 1 if Industry is in Top 50% of Industries Receiving VC Funds	R&D Intensity for Mature Compustat Firms		Intangibles Intensity for Mature Compustat Firms	
		Level	Indicator	Level	Indicator
Log VC × VC sensitivity	0.006 (0.001)***	0.096 (0.030)***	0.004 (0.002)**	0.004 (0.001)***	0.002 (0.001)*
Post-branching × bank sensitivity	0.001 (0.006)	0.001 (0.006)	0.001 (0.006)	0.003 (0.006)	0.003 (0.006)
Post-interstate × bank sensitivity	0.009 (0.009)	0.009 (0.009)	0.009 (0.009)	0.011 (0.009)	0.011 (0.009)
Industry share of employment	0.139 (0.027)***	0.142 (0.027)***	0.147 (0.027)***	0.139 (0.027)***	0.148 (0.027)***
Observations	7,459	7,459	7,459	7,459	7,459
Fixed effects	State × Year Industry × Year				
R^2	0.42	0.42	0.42	0.43	0.42

Table VI
Venture Capital and Large Firm Employment Size: Instrumenting VC with Pension Funds Assets

The first panel of the table reports the percentage change in VC finance induced by changes in the size of state and local pension funds. The size of pension funds is proxied by total assets of state and local pension funds, in constant 1980 dollars. The regression includes state and year fixed effects. The second panel presents estimates of the percentage change in the average size of business firms in the top bin of the size distribution as a result of VC finance. Each column reports statistics from a fixed effect regression, where the dependent variable is the log of average enterprise employment size in the 100+ bin (columns labeled "100+ employees"), and the log of average enterprise employment size in the 100-500 bin (columns labeled "100-500 employees"). The terms of interaction are based on VC allocation by industry, on R&D intensity for mature Compustat firms, and on intangibles intensity for mature Compustat firms (see Table II for details). Data on establishments are from the County Business Patterns, 1977-1997. Data withheld for confidentiality purposes are reported as "0" in the original file, and are consequently treated as missing observations. The VC series comes from the National Venture Capital Association (NVCA), 1980-2001, and is deflated into constant 1980 dollars. The bank deregulation variables are dummies equal to 1 in the year after the lifting of intrastate branching restrictions and on; data from Amel (1993). Data on pension funds assets come from the US Census Bureau, 1992-1997. The analysis is performed on a panel covering the period 1980-1997. Industry share of employment equals the total employment in a given industry-state-year divided by the total employment in the corresponding state-year. White (1980) standard errors appear below each coefficient in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

	First stage
Log total assets of local and state pension funds	0.034 (0.002)***
Observations	300
State fixed effect	Yes
Year fixed effect	Yes
R^2	0.90

	Second stage					
	VC sensitivity measure					
	Indicator = 1 If Industry is in Top 50% of Industries Receiving VC Funds		Level of R&D Intensity for Mature Compustat Firms		Level of Intangibles Intensity for Mature Compustat Firms	
	100+ employees	100-500 employees	100+ employees	100-500 employees	100+ employees	100-500 employees
Log VC × VC sensitivity	0.015 (0.006)**	0.013 (0.003)***	0.249 (0.115)**	0.346 (0.0733)***	0.002 (0.003)	0.006 (0.002)***
Industry share of employment	0.241 (0.082)***	0.112 (0.05)**	0.255 (0.082)***	0.117 (0.05)**	0.277 (0.081)***	0.117 (0.05)**
Observations	1,614	2,577	1,614	2,577	1,614	2,577
Fixed effects	State × Year Industry × Year					
R^2	0.63	0.44	0.63	0.43	0.63	0.44

Table VII
Venture Capital, Banks, and Large Firm Employment Size: Errors-in-variables

The table reports estimates of the percentage change in the average size of business firms in the top bin of the size distribution as a result of VC finance. Each column reports statistics from a fixed effect regression, where the dependent variable is the log of average enterprise employment size in the 100+ bin. The results are from OLS regressions as in Table V (columns labeled "OLS") and from IV regressions as in Table VI (columns labeled "IV"). The terms of interaction are based on VC allocation by industry, on R&D intensity for mature Compustat firms, and on intangibles intensity for mature Compustat firms, for VC interactions, and on the measure of sensitivity to bank finance from Cetorelli and Strahan (2006), for bank deregulation interactions (see Table II for details). All observations have been averaged over 3-year periods (1980-1982, 1983-1985, 1986-1988, 1989-1991, 1992-1994, 1995-1997). Data on establishments are from the County Business Patterns, 1977-1997. Data withheld for confidentiality purposes are reported as "0" in the original file, and are consequently treated as missing observations. The VC series comes from the National Venture Capital Association (NVCA), 1980-2001, and is deflated into constant 1980 dollars. The bank deregulation variables are dummies equal to 1 in the year after the lifting of intrastate branching restrictions and on; data from Amel (1993). The analysis is performed on a panel covering the period 1980-1997. Industry share of employment equals the total employment in a given industry-state-year divided by the total employment in the corresponding state-year. White (1980) standard errors appear below each coefficient in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

	VC sensitivity measure					
	Indicator = 1 If Industry is in Top 50% of Industries Receiving VC Funds		Level of R&D Intensity for Mature Compustat Firms		Level of Intangibles Intensity for Mature Compustat Firms	
	OLS	IV	OLS	IV	OLS	IV
Log VC × VC sensitivity	0.016 (0.004)***	0.012 (0.009)	0.094 (0.069)	0.144 (0.171)	0.006 (0.002)***	0.004 (0.005)
Post-branching × bank sensitivity	-0.001 (0.015)	0.109 (0.062)*	-0.001 (0.015)	0.108 (0.062)*	0.003 (0.015)	0.106 (0.062)*
Post-interstate × bank sensitivity	0.039 (0.027)	-0.036 (0.298)	0.035 (0.027)	-0.065 (0.298)	0.038 0.027)	0.019 (0.314)
Industry share of employment	0.112 (0.066)*	0.108 (0.125)	0.139 (0.066)**	0.118 (0.126)	0.139 (0.066)**	0.128 (0.124)
Observations	1,995	674	1,995	674	1,995	674
Fixed effects	State × Year Industry × Year					
R^2	0.61	0.61	0.61	0.61	0.61	0.61

Table VIII
Venture Capital, Banks, and Average Large Firm Employment Size: Adding 1998-2001

The table reports estimates of the percentage change in the average size of business firms in the top bin of the size distribution as a result of VC finance. Each column reports statistics from a fixed effect regression, where the dependent variable is the log of average enterprise employment size in the 100+ bin. The terms of interaction are based on VC allocation by industry, on R&D intensity for mature Compustat firms, and on intangibles intensity for mature Compustat firms, for VC interactions, and on the measure of sensitivity to bank finance from Cetorelli and Strahan (2006), for bank deregulation interactions (see Table II). Data on establishments are from the County Business Patterns, 1977-2001. The data come in SIC codes for 1977-1997 and in NAICS codes for 1998-2001, and so the second part of the series is also converted into SIC codes. The following SIC industries are dropped due to lack of perfect matching between SIC 1987 and NAICS 1997: 22 (Textile mills); 23 (Apparel and other textile); 35 (Industrial machinery and equipment); 36 (electronics and other electric equipment); 38 (Instruments and related products); and 39 (Miscellaneous manufacturing). In addition, both SIC industries 20 (Food and kindred products) and 21 (Tobacco products) and NAICS industries 311 (Food) and 312 (Beverages and tobacco) are merged into 1 class before matching. Data withheld for confidentiality purposes are reported as "0" in the original file, and are consequently treated as missing observations. The VC series comes from the National Venture Capital Association (NVCA), 1980-2006, and is deflated into constant 1980 dollars. The bank deregulation variables are dummies equal to 1 in the year after the lifting of intrastate branching restrictions and on; data from Amel (1993). The analysis is performed on a panel covering the period 1980-2001. Industry share of employment equals the total employment in a given industry-state-year divided by the total employment in the corresponding state-year. White (1980) standard errors appear below each coefficient in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

	VC sensitivity measure					
	Indicator = 1 If Industry is in Top 50% of Industries Receiving VC Funds		Level of R&D Intensity for Mature Compustat Firms		Level of Intangibles Intensity for Mature Compustat Firms	
	OLS	IV	OLS	IV	OLS	IV
Log VC × VC sensitivity	0.021 (0.003)***	0.012 (0.005)***	0.261 (0.054)***	0.506 (0.198)**	0.004 (0.001)***	0.02 (0.008)**
Post-branching × bank sensitivity	-0.057 (0.032)*	0.344 (0.142)**	-0.053 (0.032)	0.369 (0.145)**	-0.052 (0.032)	0.333 (0.148)**
Post-interstate × bank sensitivity	0.128 (0.048)***	-0.243 (0.316)	0.126 (0.049)***	-0.189 (0.322)	0.123 (0.049)**	-0.266 (0.331)
Industry share of employment	0.224 (0.028)***	0.28 (0.043)***	0.249 (0.028)***	0.299 (0.044)***	0.238 (0.028)***	0.275 (0.046)***
Observations	3,794	1,703	3,794	1,703	3,794	1,703
Fixed effects	State × Year Industry × Year					
R^2	0.66	0.68	0.65	0.67	0.65	0.64

Table IX
Venture Capital and Size Shares

The table reports estimates of the change in the share of business firms in different bins of the establishment size distribution as a result of VC finance. Panel A reports the results from an OLS regression where the dependent variable is the respective size share, whereas in Panel B the dependent variable has been transformed using the logit function, log{Share/(1-Share)}. The terms of interaction are based on VC allocation by industry (see Table II for details). Data on establishments are from the County Business Patterns, 1977-1997. Data withheld for confidentiality purposes are reported as "0" in the original file, and are consequently treated as missing observations. The VC series comes from the National Venture Capital Association (NVCA), 1980-2006, and is deflated into constant 1980 dollars. The analysis is performed on a panel covering the period 1980-1997. Industry share of employment equals the total employment in a given industry-state-year divided by the total employment in the corresponding state-year. White (1980) standard errors appear below each coefficient in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level. In Panel A, the coefficients on VC are multiplied by 100.

Panel A. OLS Regression results

	Share of Establishments with			
	Fewer than 100 Employees	100-250 Employees	250-500 Employees	500+ Employees
Log VC × VC sensitivity	-0.762 (0.072)***	0.195 (0.042)***	0.302 (0.031)***	0.225 (0.022)***
Industry share of employment	-0.462 (0.013)***	0.236 (0.008)***	0.152 (0.006)***	0.068 (0.004)***
Observations	8,506	11,771	10,565	8,888
Fixed effects	State × Year Industry × Year			
R^2	0.75	0.63	0.53	0.48

Panel B. Logit Regression results

	Share of Establishments with			
	Fewer than 100 Employees	100-250 Employees	250-500 Employees	500+ Employees
Log VC × VC sensitivity	-0.041 (0.005)***	0.02 (0.005)***	0.067 (0.007)***	0.098 (0.009)***
Industry share of employment	-3.412 (0.094)***	3.248 (0.103)***	3.561 (0.041)***	2.897 (0.161)***
Observations	8,506	11,771	10,565	8,888
Fixed effects	State × Year Industry × Year			
R^2	0.82	0.68	0.64	0.67

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