A Model of Financial Rents

Cyril Monnet

University of Bern and SZ Gerzensee

Sangeeta Pratap*

Hunter College and City University, New York

Erwan Quintin

University of Wisconsin – Madison

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Abstract

We develop a model of Venture Capital (VC) founded on Lucas' span-of-control model to make the case that the size distribution of VC firms provides a natural test of whether financial rents are driven by skill in finance. Specifically, in model where venture capitalists differ in skills, the dispersion in the size of VC firms should rise during booms and fall during busts. We use evidence form the dot.com boom bust to perform the associated test.

Keywords: venture capital; financial rents, span of control

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Preliminary and incomplete

*Emails: cyril.monnet@gmail.com, spratap@hunter.cuny.edu, and equintin@bus.wisc.edu.

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1 Introduction

"I confess to an uneasy Physiocratic suspicion, perhaps unbecoming in an academic, that we are throwing more and more of our resources, including the cream of our youth, into financial activities remote from the production of goods and services, into activities that generate high private rewards disproportionate to their social productivity." *James Tobin, in "On the Efficiency of the Financial System," 1984.*

The size of the financial sector and the compensation associated with financial services and activities have increased drastically over the past three decades as documented by Philippon and Reshef (2011) and Greenwood and Scharfstein (2013), among others. This explosion of the finance sector is reviving the question classically associated with Tobin (1984) of whether too many resources are being drawn to Finance: Bolton, Santos and Sheikman (2011) make a theoretical case that financial rents are in fact excessive. In their view, opaque markets populated by a finite mass of investors endowed with superior information cream-skim the highest quality assets. Originators give up rents to those financiers for fear of being relegated to exchanges where investors cannot tell good assets apart from bad assets.

An alternative view is that financial rents, instead, are fair compensation for the provision of a fixed factor and driven by skill. Holmstrom and Tirole (1997) propose a model where financiers contribute a blend of financial and human capital. Specifically, financiers have a superior ability to monitor the recipients of loanable funds and justly compensated for the fact that mitigate moral hazard frictions between operators and investors. Similarly, Mello and Quintin (2019) argue that mezzanine financiers provide a blend of financial capital and back-up operating skills so that their presence, as in Holmstrom and Tirole (1997), can turn negative NPV investments into positive NPV investments even when other investors could finance the whole venture alone.

Arguably the most likely sector where financiers contribute much more than simply capital is Venture Capital and, bore broadly, start-up financing. Not surprisingly (see Kaplan and Lerner, 2017, for a review) Venture Capital data has been extensively mined for evidence that financial rents are driven by skill rather than luck. The result of these studies has been mixed in part because measuring outcomes is highly problematic in a sector where success and failure can take many different forms, eventual payoffs can take decades to fully materialize, and success is driven by a few data points while most investments are quietly abandoned. In this paper, we propose a different approach to studying venture capital for evidence that skills are an important driver of financial rents. We lay out a model in the spirit of Lucas (1978) where venture capitalists are heterogeneous in talent and have a limited span of control. Such a model implies a specific distribution of venture capitalist size and, critically for our purposes, implies that the size distribution should become more disperse during booms and less disperse during busts. Since the relatively short history of venture capital in the United States has been marked chiefly by a massive boom during the 1990s followed by a sharp correction following the dot.com collapse, venture capital data constitutes an ideal laboratory for testing this prediction, as we do this paper.

2 The environment

Time is discrete and continues forever. The economy is populated by a mass $\bar{N}$ of infinitely-lived experts each with unbounded access to outside capital at a net rate of interest $R > 0$. In addition, a mass ϕ of households are born each period with no endowment and without access to capital markets. Households die with probability ϕ at the end of each period so that the stationary population size is one.

Households are endowed with a unit of time each period. They can devote part of this time endowment to operating a linear technology with return $w<1$ per unit of time. They can also supply labor to other households who have drawn an idea at the start of the period. We refer to the mass A_t of old households who have an idea at a given date t and employ other households as entrepreneurs. This mass is also the probability that any given household receives an idea at date t. In particular, the arrival of idea is independent of both wealth and age.

We will restrict parameters so that the fraction of labor employed by entrepreneurs is always interior. As a result, the market clearing price of labor is w throughout. Henceforth we will treat this value as a parameter to economize on notation.

For simplicity, we assume that households seek to maximize the expected value of their final-period wealth. As a result, households who are alive at date $t+1$ start the period with wealth

$$a_{t+1} = a_t R + y_t$$

where a_t is their wealth at the start of date t while y_t is their net income in that period. Realized income depends on whether or not they receive an idea and whether the idea is successfully implemented, as we will explain below.

The proportion of households who get an idea in a particular period is a function of the mass of ideas drawn in the previous period. This is a learning externality a la Romer (1986, 1991) which in our model will play the role of generating boom-bust patterns in expertise rents. For now we simply assume that $A_{t+1} = g_A(A_t) \in [0, 1]$ for all t where g_A is an increasing function an the initial stock $A_0 \geq 0$ of ideas is given.

Experts can become trained experts in any given period. For now, we assume that training is free so that all untrained experts attempt to become trained in each period. Analogously to the evolution of ideas, expert training is successful with a probability that may depend on the mass of trained experts in the previous period. Specifically, $N_{t+1} = g_N(N_t) \in [0, \bar{N}]$ for all t where g_N is an increasing function and the initial mass $N_0 \geq 0$ is given.

In the period in which experts become successfully trained, they draw their talent once and for all from a known distribution μ. This set-up implies that the distribution of talent among trained experts never change. In order for an idea to generate output, it needs to be combined with four ingredients. First, a unit of capital has to be installed at the start of the period. Second, the entrepreneur needs to privately exert some effort at a disutility cost κ. If the entrepreneur exerts effort, the idea becomes productive with probability $\pi \in (0, 1)$. Absent entrepreneurial effort, ideas are useless with certainty. Third, production requires an input of unskilled labor provided by young entrepreneurs. Fourth and finally, the project needs to be managed/monitored by a trained expert.

Trained experts have a limited span of control in the sense of Lucas (1978). Specifically, if an expert of talent $z > 0$ manages an interval $[0, n]$ of entrepreneurs who employ labor $l(i)$ for $i \in [0, n]$ and all exert effort, the total net operating income is

$$z^{1-\eta}\pi \left[\int_0^n l(i)^\alpha di - w \int_0^n l(i) di \right]^\eta$$

where both α and η are in $[0, 1]$. It is optimal for both experts and entrepreneurs to maximize the bracketed expression which implies that net operating income is, at the most,

$$z^{1-\eta}\Theta n^\eta$$

where

$$\Theta = \pi(1-\alpha)\alpha^{\frac{1}{1-\alpha}} w^{-\frac{\alpha}{1-\alpha}}.$$

Net profits generated by trained experts depend on how much surplus they have to share with entrepreneurs. We assume that trained experts behave competitively and that entrepreneurs are free to offer their services to any active expert they wish. It follows that all entrepreneurs of a particular wealth level $a \geq 0$ must expect the same surplus $q_t(a)$ from all active experts.

Before sharing surplus however, trained experts must first induce entrepreneurs to exert effort. A contract between an entrepreneur of wealth $a \geq 0$ and an expert features a contribution $0 \leq e \leq a$ of capital by the entrepreneur to the unit investment required by the project. Without loss of generality we assume that $e = a$ at all contracts since it is always at least weakly optimal for experts to require maximal investment by entrepreneurs in exchange for actuarially fair transfers at the end of the period.

Next the contract gives a payoff $w_H(a) \geq 0$ if the idea becomes productive and $w_L(a) \geq 0$ otherwise. Inducing the entrepreneur to exert effort requires:

$$\pi w_H(a) + (1-\pi) w_L(a) \geq w_L(a) + \kappa$$

at any equilibrium participation contract. Participation by entrepreneurs requires that

$$\pi w_H(a) + (1-\pi) w_L(a) \geq q_t(a).$$

Potentially many contracts solves this problem. One entails setting $w_L(a) = 0$ in which case the entrepreneur is offered a pure equity contract. Other solutions may feature $w_L(a) > 0$ which can be implemented with a fixed-payment note together with an equity participation in profits.

Note that because $w_L(a) \geq 0$ effort cannot be induced unless

$$q_t(a) \geq \kappa.$$

This strictly positive upper bound on entrepreneur surplus means that, in principle, in some equilibria there is an excess supply of idea at price κ. We will restrict parameters (assume that κ is low enough throughout, e.g.) so that rationing of funds and expertise never occurs.

Independently of the implementation specifics, the maximal total payoff from production for active experts at the end of the period is

$$\Pi(n; z, q_t) = z^{1-\eta} \Theta n^{\eta} - \int_0^n q_t(a(i)) di - \int_0^n (1 - a(i)) R.$$

Since experts are free to deal with any entrepreneurs they wish, it must be that

$$q_t(a(i)) - a(i))R$$

is almost surely a constant, which we denote by q_t. One simple way to interpret q_t is as the surplus entrepreneurs with no wealth expect at date t. Taking the idea price q_t as given, active experts maximize:

$$\Pi(n; z, q_t) = z^{1-\eta} \Theta n^{\eta} - n(q_t + R). \tag{1}$$

It is profitable for a trained expert to buy ideas for a going price q_t per project if and only if

$\max_n \Pi(n; z, q_t) \geq 0$. Write

$$n^*(z; q_t) = \arg\max_n \Pi(n; z, q_t)$$

for the profit maximizing span of an expert of talent z when the unit price of ideas is $q_t > 0$. Some algebra shows that $n^*$is linear in q_t.

Because of the minimal capital scale of operation required per idea, expert participation in the market for ideas is summarized an interior threshold $\underline{z}(q_t)$ such that experts buy a positive mass ideas if and only if $z \geq \underline{z}(q_t)$. Rents are zero for an expert whose talent is exactly at the threshold and strictly positive for more talented experts.

An equilibrium in this environment boils down to a sequence $\{q_t\}_{t=0}^{+\infty}$ such that demand for ideas coincides with its supply when q_t>0 i.e.

$$N_t \int_{z \geq \underline{z}(q_t)} n^*(z; q) d\mu = A_t. \tag{2}$$

Given the exogenous laws of motions we have specified for N and A, a unique equilibrium idea price sequence exists in this environment. Furthermore, the equilibrium price of projects is uniquely pinned down by the ratio of ideas to projects.

One equilibrium object is a potentially time-varying distribution of wealth, which depends on the price of ideas. Indeed, expected income at a particular date is q_t for households with ideas. The evolution of wealth depends on the level of compensation but also on weather the idea is successful which, in turn, depends on the particular implementation adopted. In fact, it is weakly optimal for households to commit their entire wealth to entrepreneurial contract in exchange for actuarially fair payoffs and likewise, it is weakly optimal to set $w_L(a)$=0 in the compensation contract which means that equilibria can be such that entrepreneurs lose their entire wealth with positive probability. Tracking the many possible endogenous distributions of wealth that can arise in this environment is complicated. But fortunately, the set of equilibrium idea price sequences is completely independent of the wealth distribution, as expression 1 makes clear. The implications we highlight in the next section only depend on idea prices.

3 Testable predictions

As we discussed above, the ratio of ideas to trained experts suffices to pin down the price of ideas in a given period. The following result records the testable consequences of this observation.

Proposition 1. *In any given period, as the ratio $\frac{A}{N}$ of ideas to experts rises:*

1. *The price q of ideas falls while the active expert talent $\underline{z}$ falls;*

2. *The average size of trained experts rises, as does the size of incumbent experts and the size of the smallest active expert;*

3. *The dispersion in the size (measured either in number of projects managed) of active experts rises in the sense that for any $z_H > \underline{z}$*

$$\frac{E\left(n^*(z;q)|z \geq z_H\right)}{n^*(\underline{z};q)}$$

rises;

4. *If and only if μ is such that $\frac{E(z|z>\underline{z})}{\underline{z}}$ is monotonically declining in $\underline{z}$, average expert rents rise.*

Proof. The first item of the proposition follows immediately from expression 2. The average size of active experts is $\frac{A}{N}$ so it must rise and fall with that ratio. Because the price of ideas falls when $\frac{A}{N}$ rises, the size of every incumbent expert must rise as well. For the minimal size $\underline{n}$, note that we must have

$$(1-\eta)\underline{n}q = R$$

in any given period so that the minimal size of experts is inversely related to q. This establishes the second item.

As for the third item, some algebra shows that project choices are linear in expert talent so that

$$\frac{E\left(n^*(z;q)|z \geq z_H\right)}{n^*(\underline{z};q)} = \frac{E(z|z > z_H}{\underline{z}}$$

which is monotonically decreasing in $\underline{z}$. As average expert rents, some algebra show that

$$\Pi^*(z,q) = \max_n \Pi(n;z,q_t) = (1-\eta)qn^*(z;q_t) = z\left(\Theta\eta\right)^{\frac{1}{1-\eta}} q^{\frac{-\eta}{1-\eta}}.$$

In particular, it must be the case that for the marginal expert, net profits are zero:

$$\underline{z}\left(\Theta\eta\right)^{\frac{1}{1-\eta}} q^{\frac{-\eta}{1-\eta}} = R$$

so that, in turn, average rents satisfy:

$$\frac{N\int_{\underline{z}} z\left(\Theta\eta\right)^{\frac{1}{1-\eta}} q^{\frac{-\eta}{1-\eta}} d\mu}{N\int_{\underline{z}} d\mu} = \left(\Theta\eta\right)^{\frac{1}{1-\eta}} q^{\frac{-\eta}{1-\eta}} E(z|z>\underline{z}) = R\frac{E(z|z>\underline{z})}{\underline{z}},$$

and the result follows. This completes the proof. □

The predictions above are stated in terms of number of projects managed by experts rather than deployed assets under management because the capital investment needs depends on the own contribution made by entrepreneurs. In principle, a particular expert who manages a lot of project could work exclusively with high asset entrepreneurs who do not need much external capital. However, since experts are indifferent across different levels of financing required, it seems more natural to assume a mostly random allocation of entrepreneur types to experts. Under that assumption, the implications listed above hold for deployed capital under management as well as the number of projects.

To the extent that these predictions are borne out by the evidence, this should be especially clear during periods of large swings in venture capital activity, for instance during the boom-bust period that spanned the 1990-2005 period in the United States. Because of the learning externality that governs the evolution of ideas, our model is ideally suited to generated boom-busts in the ratio of ideas to active experts hence in VC rents. To see this concretely, let

$$A_{t+1} = g_A(A_t) = A_t + (\bar{A} - A_t)\frac{\bar{\delta}}{1 + \exp(-b_A A_t)}$$

for all $t \geq 1$ where $\bar{\delta} \in [0, 1]$ and $b_A > 0$, while $\bar{A}$ is the peak fraction of households who become entrepreneurs.

$$N_{t+1} = N_t + (\bar{N} - N_t)\frac{\bar{\delta}}{1 + \exp(-b_N N_t)}$$

for all $t \geq 1$ where $b_N \geq 0$, while$N_0 \in [0, \bar{N}]$ is given. These functional forms have an important property for our purposes:

Remark 1. If $b_N < b_A$ and $A_0 = N_0$ then the ratio $\frac{A_t}{N_t}$ of ideas to experts rises initially and then falls.

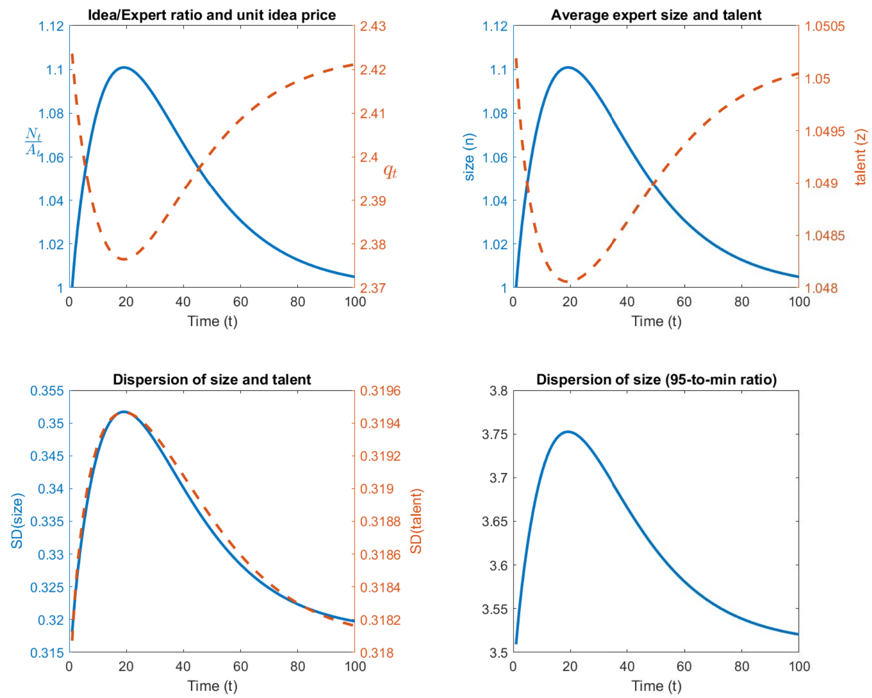
In other words, if the rate at which households learn from their successful predecessors is higher than the rate at which experts learn from their predecessors, the ratio of ideas to experts first rises and then falls. In the environment we are outlining, this will result in a hump-shape pattern in $\frac{A_t}{N_t}$. Given proposition during the boom in $\frac{A_t}{N_t}$, the unit price of ideas fall so that:

1. Both the mass of ideas and the mass of active experts increase;

2. Average experts rents rise while minimal rents stay constant;

3. The average size of experts rises as does the size of incumbent experts and the size of the least talented experts;

Figure 1: Boom-busts in VC funding and size dispersion



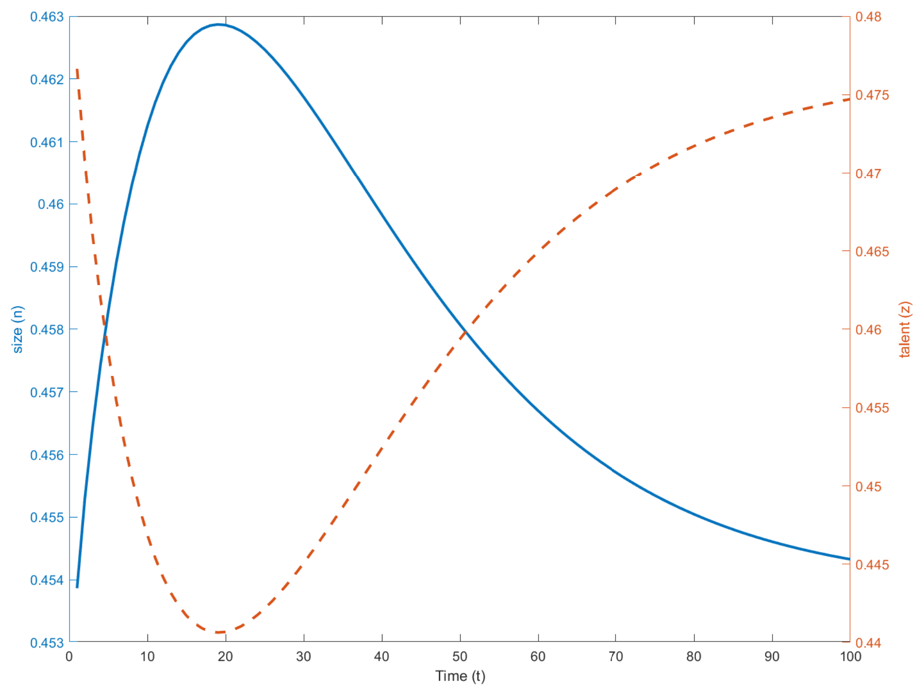
4. The dispersion in expert rents and in expert sizes increases.

Figure 3 illustrates those predictions for a parametrized version of our economy in which the distribution μ of expert talent is log-normally distributed with location parameter 0 and dispersion parameter 0.3. For the evolution of ideas and the mass of experts we set $\bar{\delta} = 0.1$ while $b_N = 0 < 2 = b_A$ and $\bar{A} = \bar{N} = 0.5$ and $A_0 = N_0 = 0.05$. The resulting boom-bust pattern in the ratio of ideas to to experts is shown in the first panel of the figure.

We set the common TFP component Θ of the expert production function to 3while we make the curvature parameters $\eta = 0.8$. The expert's gross opportunity cost of capital is $R = 1.1$ and the price of labor in each period is $w = 1$. These parameter choices result in a path of the unit price of ideas shown in the dashed line in the first panel of the figure. The resulting equilibrium size of expert's holdings is shown in the second panel of the figure. It grows during the booms and falls during the fall, while the average talent of experts follows the exact opposite pattern. Less talented producers start participating during the boom because the unit price of ideas falls.

As the support of active producers of talent widens, the dispersion in the size of expert portfolios increases during the boom but eventually falls during the bust, as shown in the bottom two panels

Figure 2: Minimal expert talent and size



of the figure. The first panel in the bottom raw computes the standard deviation of size while the second one reports the 95th percentile of expert portfolio size relative to the smallest portfolio among active producers.

Part of the increase in dispersion comes from the fact that the minimum talent level among active producers falls during the boom. However, the model predicts that the minimum size $\underline{n}$ of active portfolios among active experts must rise during the boom. Indeed, profits for the marginal producers must satisfy:

$$(1-\eta)\underline{n}_t q_t = R.$$

Since q falls during the boom, $\underline{n}$ must rise,. This opposite behavior of minimal expert talent and minimal expert size is show in figure 3.

4 Venture Capital data

4.1 Overview of the Venture Capital Industry

Most VC firms in the United States are corporations held by a small number of partners that raise money from wealthy individuals, pension funds, insurance companies and other financial institutions. Contracts between VC firms and those investors are typically structured as funds, i.e.limited partnerships in which the firm assumes all management responsibility and liability as the General Partner (GP) while investors are limited partners (LPs). Figure 3 provides a schematic representation of the of the VC industry.

Fund contracts usually feature a target size and are closed to new investments once that size is reached and stipulate a date by which money has to be returned to investors and the limited partnership is terminated. VC firms typically earn a fixed fraction of the fund size (usually around 2% of assets under management) and a share of profits after all principal or principal plus a hurdle rate has been paid back to limited partners. VC firms often manage several funds at the same time. Each fund may feature different objectives and covenants.

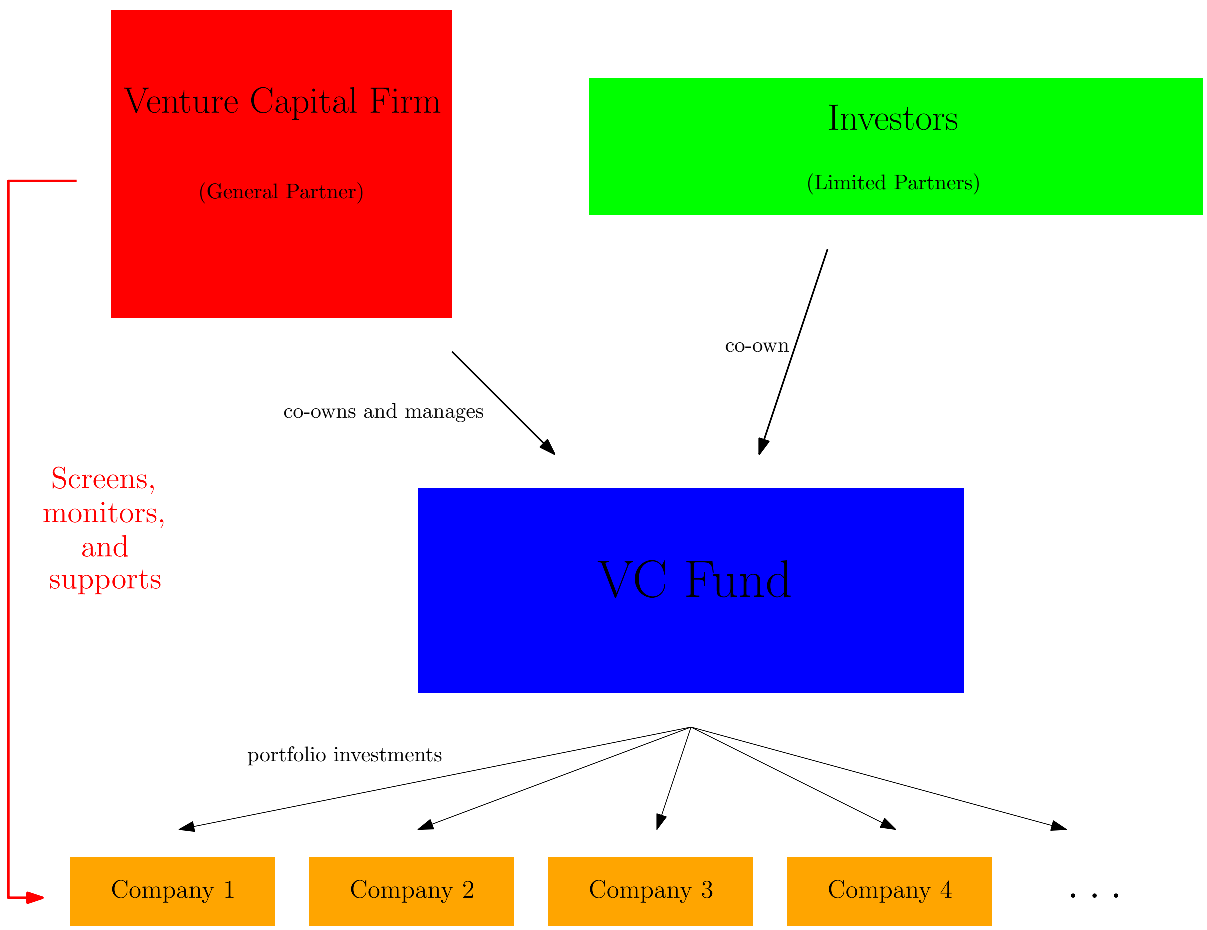
Once a fund is closed, it is the GP's sole responsibility to deploy those funds to start-up investments known as portfolio companies in accordance with each fund's objectives and restrictions. But GPs are also expected and incentivized to monitor and provide support to portfolio companies. This includes both active advice and helping portfolio companies locate clients and new "follow-on" investors.

A portfolio company receives VC funds in rounds, large one-time investment from one or more funds. The industry classifies those rounds in loosely defined, distinct categories. Seed stage rounds are small investments made in recent start-ups. Series A rounds refer to money deployed to firms that have demonstrated some viability. Series B rounds are deployments to companies with measurable results that look to scale up their operations or gain market shares. Series D rounds fund large scale expansions such as the introduction of a new product. And the list goes on. The key features of these rounds for our purposes is that they become larger with time as surviving firms go from experimentation stages to stabilization and expansion phases.

4.2 VentureXpert

Our main source of data is a Thomson Reuters database of Venture Capital firms, funds, investments, and funded companies known as VentureXPert (VE). These data contain self-reported information on investment by funds into portfolio companies, starting in 1961 but with improvements after 1980. We use all investment rounds between 1985 and 2010. Kaplan, Sensoy and

Figure 3: The structure of the VC industry



Stromberg (2002) find that VentureXpert data include about 95 percent of all financing rounds and understate total investment. They also oversample California. Rounds are included in 98.4 percent of cases for California, 89.5 percent for other states. Bigger rounds are more likely to be included than smaller rounds. However, round amounts are noisy but do not appear to be biased, which is critical for our purposes.

4.3 Mapping from model to data

We measure portfolio sizes (n, in our model) by summing up all investments made by a given VC firm in a particular year. One practical difficulty is that for rounds involving multiple firms only the total amount deployed is known. In that case and as a first pass, we allocated the total amount equally across participants. We will also show fund size distribution by way of robustness.

5 Empirical tests

5.1 Cross-sectional regression

Is the size of firm portfolios systematically correlated with firm characteristics such as age, VC experience (follow on fund?), geographical area of origin?

5.2 Time-variation in portfolio size variation

Does the average size of firm portfolios and the dispersion of size increase during the boom and fall during the bust? At this preliminary stage, we can only look at broad statistics, but will have completed the econometrics by the summer. Figure 4 display the boom-bust in total VC deployment during the 1990-2005 period which creates the ideal laboratory to test our theory. Consistently with our theory, it also shows that average size of portfolio across VC firms and total deployments co-move tightly.

Figure 5 shows that the standard deviation of portfolio shows at best slight tendency to increase during the boom while the associated coefficient of variation is flat both at the VC firm and the fund level. Figure 6 shows that 90-10 measures of dispersion show little pattern during the boom and the bust. The bottom of the figure, in particular, shows that both the bottom end and the top end of the distribution appear to move in parallel.

Figure 4: Total VC Investment ($M, real)

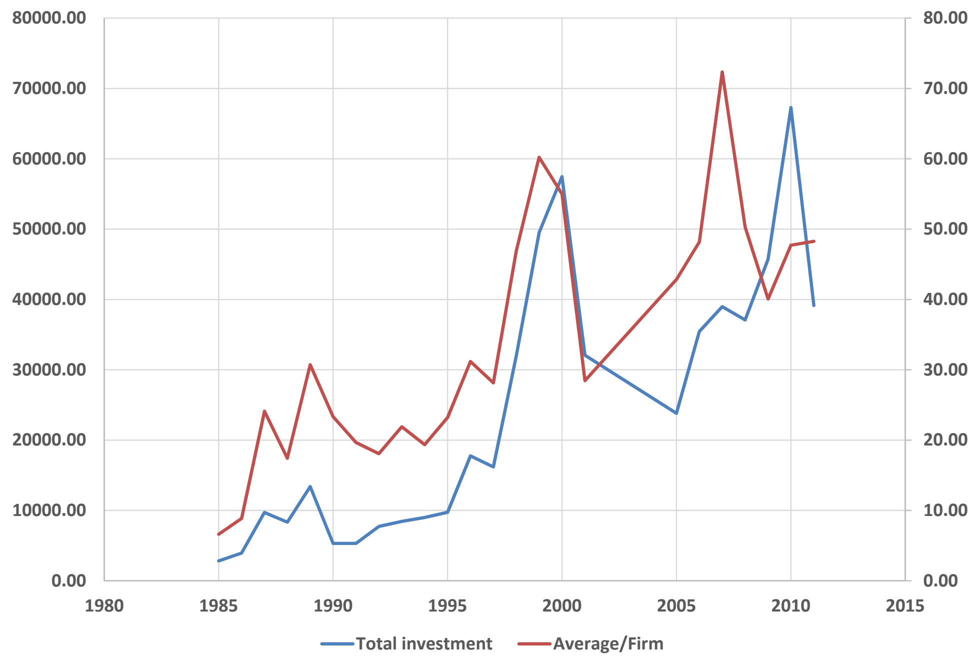
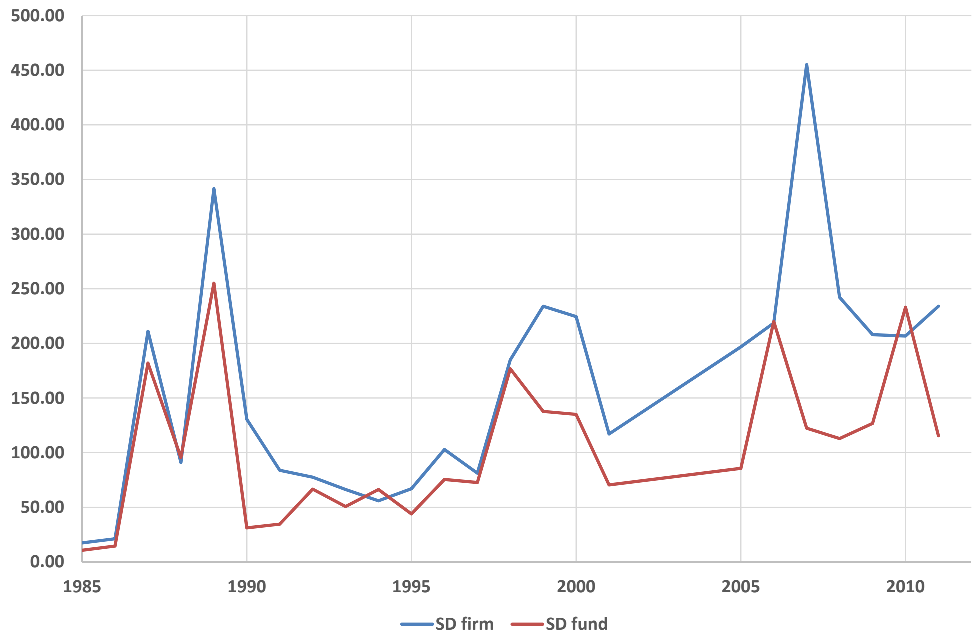


Figure 5: Dispersion measures



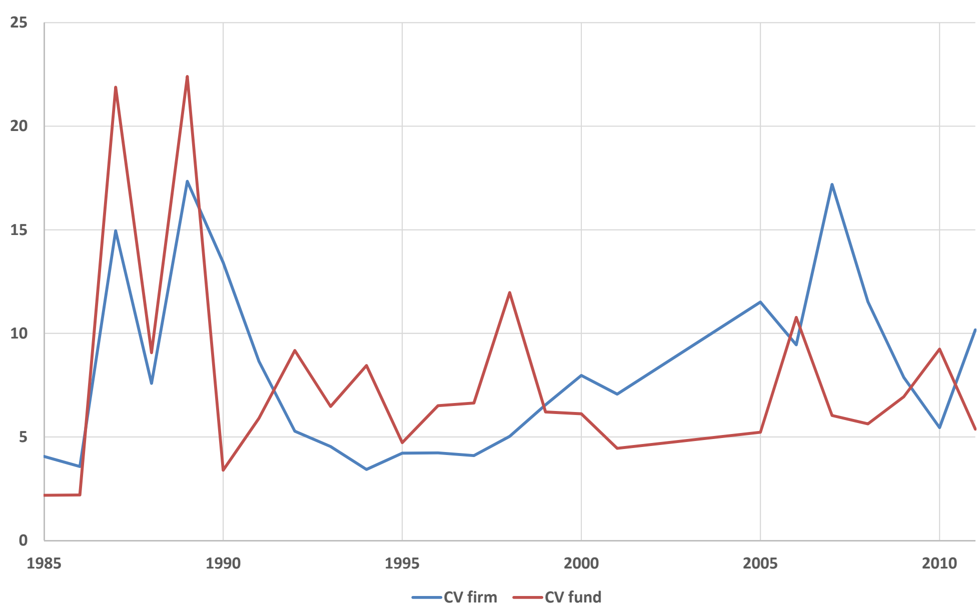
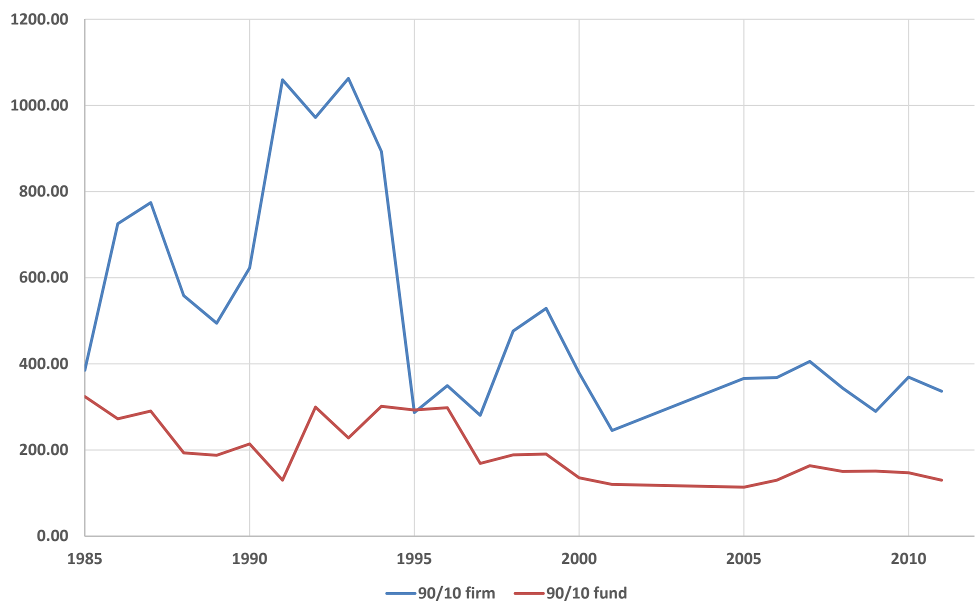


Figure 6: 90-10 dispersion



6 Conclusion

TBA

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