Venture Capital Contracts

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Efficient allocation of start-up resources is first-order important. High uncertainty, large information asymmetries, severe agency problems, limited liability ⇒ contracts matter.

Predominant theory: Contracts can provide optimal incentives and information sharing, improving start-up value.

- Typically, assume competitive VCs who do not participate in value creation.

Alternative view: VCs can skew the distribution of value in their favor, even if this reduces the overall start-up value.

- VCs have deal flow access, skill & participate in value creation ⇒ bargaining power. Limited liability & incomplete contracts misalign VC’s and overall start-up’s goals.

To date, little empirical evidence on this debate.
Contribution

Use new, large data set of VC contracts and dynamic search and matching model to estimate the impact of contract terms on:

- Start-up value;
- Split of value between VC and entrepreneur.

**Main results:**

VCs add value to startups:

- Higher quality VCs (who offer participating preferred and board seats) ⇒ higher start-up value and entrepreneur stake
- ... but not as much as possible if they used different contract terms.

Major contract terms affect start-up value and its split:

- Optimal equity split between VC and entrepreneur.
- Participating preferred decreases value, shifts higher proportion to VCs.
- Board seat impact is nuanced and smaller.
- Pay-to-play increases value and shifts higher proportion to entrepreneur.
Identification challenge

In an ideal world, run regression of outcomes (e.g. IPOs) on contract terms.

BUT: omitted variable bias.
  - VC and entrepreneur quality affects matches, contracts, and outcomes.
  - Quality is (largely) unobserved.

We illustrate bias in the presence of search frictions in the VC market.
  - Useful to understand our identification strategy.
Identification example: setup

Three VCs of quality $i = 1, 2, 3$.
Three entrepreneurs of quality $e = 1, 2, 3$.
Value of a match between entrepreneur and VC:

$$\pi = i \cdot e \cdot \exp\{-2.5 \cdot c\}, \text{ or } \log \pi = \log i + \log e - 2.5 \cdot c.$$ 

Assume common equity contracts, with VC receiving equity fraction $c$.

- For example, If $i = 1$ and $e = 2$ match with $c = 0.4$, then:
  - $\pi = 2 \cdot \exp\{-1\} = 0.74$.
  - VC receives 40% of $\pi$ and entrepreneur retains 60%.

VCs and entrepreneurs search and randomly encounter counterparties. A match is made if

- VC quality is in entrepreneur’s acceptable range.
- Entrepreneur quality is in VC’s acceptable range.
Identification example: matches

If $i$, $e$, $c$, and $\pi$ are observed, then the OLS regression

$$\log \pi = \beta_1 c + \beta_2 \log i + \beta_3 \log e + \epsilon$$

is identified and yields the correct coefficients,

$$\beta_1 = -2.5, \beta_2 = 1, \beta_3 = 1.$$
In practice, \( i \) and \( e \) are unobserved, so running
\[
\log \pi = \beta_1 c + \varepsilon
\]
yields biased \( \beta_1 = 2.04 \).

Omitted variables \( i \) and \( e \) are in the residual, and correlated with \( c \).
Bias generally ambiguous: Better (worse) VCs (entrepreneurs) get higher \( c \).
Traditional solutions are limited

It is difficult to find instruments/experiments that vary contracts but not VC/entrepreneur matches.

VC and entrepreneur fixed effects could help, however:
- Need to estimate a parameter for each agent ⇒ less statistically efficient.
- Most entrepreneurs (and some investors) match once ⇒ cannot estimate f.e.

We use a **model of selection** to recover unobservable qualities:
- Matches and contract terms are chosen by agents in equilibrium ⇒ informative about qualities.
- Recovery of individual $i$ and $e$ is difficult: different $(i, e)$ may sign same contract.
- A feasible approach:
  - Individual $i$ and $e$ combine into agent quality distributions.
  - ⇒ equilibrium distribution of matches, contract terms and exits in successful matches.
  - ⇒ recover quality distributions by fitting equilibrium to data.
Dynamic search and matching model

VCs randomly encounter entrepreneurs with Poisson intensity $\lambda_i$:
- Entrepreneur quality drawn i.i.d. from c.d.f. $F_e(e)$ on $[e, \bar{e}]$.

Similarly, entrepreneurs randomly encounter VCs with intensity $\lambda_e$:
- Investor quality drawn i.i.d. from c.d.f. $F_i(i)$ on $[i, \bar{i}]$.

If agents match, PV of future cash flows is $\pi(i, e, c)$.

VC optimally proposes a take-it-or-leave-it set of contract terms $c$:
- Formally, $c(i, e) = \arg \max_{c \in C : \pi_e(i, e, c) \geq V_e(e)} \pi_i(i, e, c)$.
- Limited liability + risky cash flows $\Rightarrow$ fixed-amount cash transfers are infeasible.
- If accepted, VC receives $\pi_i = \alpha(c)\pi$, entrepreneur retains $\pi_e = (1 - \alpha(c))\pi$.
- If not accepted, both agents resume their search.
  - Search is costly: agents discount future at rate $r$.
- $\Rightarrow$ VCs and entrepreneurs have bargaining power: they can keep searching.
  - Model allows competitive VCs as a special case.
Implementation: value

Assume quality distributions \( F_i \sim \text{Beta}(a_i, b_i) \) and \( F_e \sim \text{Beta}(a_e, b_e) \):

- Discretize \((i, e)\) on a 50x50 grid.

**Reduced-form** firm value:

\[
\log \pi = \log \text{Costant Elasticity of Substitution}(i, e; \rho) + \beta_1 c_1 + \beta_2 c_1^2 + \beta_3: #T + 1 \cdot \text{Terms} + \beta_{#T + 2: #T + #I + 1} \cdot \text{Interactions}.
\]

- \( \rho = -\infty \): qualities are perfect complements; \( \rho = 1 \): qualities are perfect substitutes.
- \( c_1 \): the VC share of equity upon conversion.
  - Quadratic specification allows for an internal optimal equity share.
- **Terms**: other contract terms interacted with VC equity:
  - The impact of other terms is the highest for intermediate values of VC equity.
  - It is zero when VC equity is either 0 or 100%: term is either irrelevant or VC already gets all the value.
- **Interactions**: all cross-interactions among other terms.

- **Directly model impact of terms on values (and split)**, agnostic about mechanisms.
Implementation: split of value, outcome

**Reduced-form** split of value:

\[
\log(1 - \alpha(c)) = \log(1 - c_1) \\
+ \gamma_1 (1 - c_1) + \gamma_2 \cdot \text{Terms} + \gamma_{#T+1} \cdot \text{Interactions}.
\]

- When \(\text{Terms} = \emptyset\) (common equity contract), \(\alpha(c) = c_1\).
- Other terms are mostly VC-friendly, pushing \(\alpha(c) > c_1\).
- \(\gamma_1\) captures the effect of other terms omitted from the contract space.
  - Some terms are always present in the data, or are considered unimportant.
  - The most important of these terms is liquidation preference.
  - It is zero when VC equity is 100% but strongest when VC equity is 0 \(\Rightarrow \gamma_1\) is interacted with VC equity.

Since \(\pi\) is not observed directly, specify **success probability**:

\[
\text{Prob}(\text{Success} = 1|i,e,c) = \Phi(\kappa_0 + \kappa_1 \pi(i,e,c)).
\]

Estimate quality distributions, encounter frequencies, \(\beta, \gamma\), and \(\text{Success}(\pi)\) via method of moments.
Identification in GMM: contract terms

Model produces joint distribution of time between deals across VCs, contract terms, and success outcomes.

We use all first and second moments (including all covariances).

Parameters mainly shift specific moments, and can be identified from them:

- $\beta \cdot Terms$: higher impact of a contract term on value changes both the incidence of this term and the likelihood of success (via higher value):
  - Identified from Avg. (and Var., for equity) term and Cov. term and success rate.
- $\gamma \cdot Terms$: higher impact of a contract term on split of value only changes the incidence of this term:
  - Identified from the remaining information in Avg. term.
- $\beta \cdot Interactions, \gamma \cdot Interactions$: higher impact of term interactions on value and split changes the joint likelihood of these terms:
  - Identified from Cov. term1 and term2.
Parameters mainly shift specific moments, and can be identified from them:

- $\lambda_i, \lambda_e$: higher meet frequencies decrease average $E[\text{time}]$ between deals across VCs but have opposite effects on the dispersion of $E[\text{time}]$ between deals across VCs:
  - Identified from Avg. and Var. time since last VC financing.

- $a_i, b_i, a_e, b_e, \rho$: jointly impact time between VC deals and terms (by shifting bargaining power across and within VCs and entrepreneurs):
  - Identified from Cov. time since last VC financing and term.

- $\kappa_0, \kappa_1$: higher value changes the likelihood of success:
  - Identified from Avg. success rate and Cov. time since last VC financing and success rate.
Data

  o DowJones VentureSource, VentureEconomics, Pitchbook, and Correlation Ventures.

Contract data from Pitchbook and VC Experts.
  o Collected from articles of incorporation (CA and DE).
  o At least 86% of all VentureSource start-ups are incorporated in CA or DE.

First rounds only (seed or series A) with a lead VC investor.
  o Follow-on rounds different due to existing contracts with prior investors.
  o Non-VC leads may have objectives other than profit maximization.
  o Restrict to rounds using an equity-type security.

Outcome variable: IPO or high-value acquisition within seven years of first financing round.

Main sample: **1,695 contracts** (robustness: >2,500 contracts).
### Firm and exit statistics

<table>
<thead>
<tr>
<th>Deals</th>
<th>Number</th>
<th>Mean</th>
<th>Median</th>
<th>St.Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm Age at financing (years)</td>
<td>1,695</td>
<td>1.62</td>
<td>1.10</td>
<td>1.70</td>
</tr>
<tr>
<td>IT</td>
<td>1,695</td>
<td>0.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthcare</td>
<td>1,695</td>
<td>0.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years since last round (VC)</td>
<td>1,695</td>
<td>0.69</td>
<td>0.28</td>
<td>1.13</td>
</tr>
<tr>
<td>Capital raised in round ($m)</td>
<td>1,695</td>
<td>7.26</td>
<td>5.20</td>
<td>8.37</td>
</tr>
<tr>
<td>Post-money valuation ($m)</td>
<td>1,695</td>
<td>21.20</td>
<td>13.01</td>
<td>39.38</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exits</th>
<th>Number</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Went public</td>
<td>1,695</td>
<td>0.04</td>
</tr>
<tr>
<td>Acquired</td>
<td>1,695</td>
<td>0.39</td>
</tr>
<tr>
<td>IPO or Acquired &gt; 2X capital</td>
<td>1,695</td>
<td>0.13</td>
</tr>
<tr>
<td>Out of business</td>
<td>1,695</td>
<td>0.13</td>
</tr>
<tr>
<td>Still private</td>
<td>1,695</td>
<td>0.43</td>
</tr>
<tr>
<td>Had follow-on within 2 years</td>
<td>1,695</td>
<td>0.73</td>
</tr>
</tbody>
</table>
VC Contracts 101

Convertible preferred equity:
- The investor holds an option to convert into common stock.

Cash flow rights:
- Liquidation preference:
  - Debt-like feature that returns a multiple of invested capital to the preferred stockholder before common equity receives any payout.
- Participation.
Convertible preferred equity

With a 1X liquidation preference the payoff figure looks as follows:

![Graph showing payoff at exit with a 1X liquidation preference.]

- **Slope = 1**
- **Slope = \( \alpha \)**
- **Investment**
- **Conversion point**
- **No conversion**
- **Convert to common**
- **Exit value**
Participating convertible preferred

Payoff figure of participating convertible preferred (uncapped) with 1X liquidation preference:

Payoff at exit

Exit value

Slope = \alpha

Slope = 1

Investment

0
Convertible preferred *equity*:
- The investor holds an option to convert into common stock.

Cash flow rights:
- Liquidation preference:
  - Debt-like feature that returns a multiple of invested capital to the preferred stockholder before common equity receives any payout.
  - **Participation**.
- Dividends.
- Redemption (put option).

Control rights:
- **VC board seat(s).**

Other: **Pay-to-play**:
- Investor loses certain cash flow and voting rights if no pro-rata participation in next round (often conversion to common equity).
Contract frequencies are similar to sample of 5,510 deals that does not require that key terms are known for every deal.

<table>
<thead>
<tr>
<th>Contracts</th>
<th>Number</th>
<th>Mean</th>
<th>St.Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity share sold to VC</td>
<td>1,695</td>
<td>0.40</td>
<td>0.17</td>
</tr>
<tr>
<td>Participating preferred</td>
<td>1,695</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td>Pay to play</td>
<td>1,695</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>VC has board seat?</td>
<td>1,695</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td>Liquidation preference &gt; 1X</td>
<td>1,689</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Cumulative dividends</td>
<td>1,694</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>Redemption rights</td>
<td>1,675</td>
<td>0.39</td>
<td></td>
</tr>
<tr>
<td>Full ratchet</td>
<td>1,013</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Common stock sold?</td>
<td>1,694</td>
<td>0.04</td>
<td></td>
</tr>
</tbody>
</table>
### OLS estimates

**Outcome** = \(\text{Const} + \beta_1 \cdot \text{Equity} + \beta_2 \cdot \text{Equity}^2 + \beta_{3:5} \cdot \text{Terms}\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>(1) IPO or 2X Acq.</th>
<th>(2) IPO only</th>
<th>(3) Log postmoney</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\beta_0)</td>
<td>Intercept</td>
<td>-4.704***</td>
<td>0.655</td>
</tr>
<tr>
<td>(\beta_1)</td>
<td>Total value, share of VC equity</td>
<td>-1.641**</td>
<td>0.964</td>
</tr>
<tr>
<td>(\beta_2)</td>
<td>Total value, share of VC equity squared</td>
<td>2.546**</td>
<td>1.088</td>
</tr>
<tr>
<td>(\beta_3)</td>
<td>Total value, participation</td>
<td>-0.238***</td>
<td>0.065</td>
</tr>
<tr>
<td>(\beta_4)</td>
<td>Total value, pay-to-play</td>
<td>0.115</td>
<td>0.133</td>
</tr>
<tr>
<td>(\beta_5)</td>
<td>Total value, VC board seat</td>
<td>0.136</td>
<td>0.198</td>
</tr>
</tbody>
</table>

- Year FE
- Year founded FE
- State FE
- Industry FE

\(R^2\) | 6.2% | 19.5% | 12.9%

**Counterintuitively, the OLS finds a **U-shaped impact of equity.**

- Result is robust to controlling for raised capital, interactions among terms.
### Model estimates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>St.Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_i$</td>
<td>1.927***</td>
<td>0.257</td>
</tr>
<tr>
<td>$b_i$</td>
<td>3.602**</td>
<td>0.760</td>
</tr>
<tr>
<td>$a^e$</td>
<td>3.142***</td>
<td>0.334</td>
</tr>
<tr>
<td>$b^e$</td>
<td>4.152***</td>
<td>0.573</td>
</tr>
<tr>
<td>$\lambda_i$</td>
<td>13.443**</td>
<td>6.096</td>
</tr>
<tr>
<td>$\lambda^e$</td>
<td>10.393***</td>
<td>2.739</td>
</tr>
<tr>
<td>$\rho$</td>
<td>-1.370***</td>
<td>0.078</td>
</tr>
<tr>
<td>$\kappa_0$</td>
<td>-4.056**</td>
<td>2.066</td>
</tr>
<tr>
<td>$\kappa_1$</td>
<td>0.104*</td>
<td>0.061</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>0.679***</td>
<td>0.220</td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>-2.362***</td>
<td>0.233</td>
</tr>
<tr>
<td>$\beta_3$</td>
<td>-0.163***</td>
<td>0.027</td>
</tr>
<tr>
<td>$\beta_4$</td>
<td>0.024</td>
<td>0.048</td>
</tr>
<tr>
<td>$\beta_5$</td>
<td>-0.026***</td>
<td>0.006</td>
</tr>
<tr>
<td>$\beta_6$</td>
<td>0.016</td>
<td>0.102</td>
</tr>
<tr>
<td>$\beta_7$</td>
<td>0.033^^</td>
<td>0.026</td>
</tr>
<tr>
<td>$\beta_8$</td>
<td>0.019</td>
<td>0.064</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>-0.211***</td>
<td>0.076</td>
</tr>
<tr>
<td>$\gamma_2$</td>
<td>-0.174***</td>
<td>0.027</td>
</tr>
<tr>
<td>$\gamma_3$</td>
<td>0.055*</td>
<td>0.029</td>
</tr>
<tr>
<td>$\gamma_4$</td>
<td>-0.040***</td>
<td>0.007</td>
</tr>
<tr>
<td>$\gamma_5$</td>
<td>0.015</td>
<td>0.113</td>
</tr>
<tr>
<td>$\gamma_6$</td>
<td>0.029^^</td>
<td>0.027</td>
</tr>
<tr>
<td>$\gamma_7$</td>
<td>0.012</td>
<td>0.107</td>
</tr>
</tbody>
</table>
Matches, contracts, and qualities

A. VC equity share

B. Participation

C. Pay-to-play

D. VC board seat

E. VC firm share

Distributions of qualities
Equity and firm value

\[ \log \pi = CES(i, e; \rho) + \beta_1 \cdot Equity + \beta_2 \cdot Equity^2 + \beta_{3:8} \cdot Terms & Interactions \]

Fix VC and entrepreneur quality.

How does firm value compare to the maximal value across all possible contracts?

First, consider convertible pref.:
- Internal optimal equity share.
- Convertible pref. alone does not achieve maximal value.
Participating preferred and firm value

\[ \log \pi = CES(i, e; \rho) + \beta_1 \cdot \text{Equity} + \beta_2 \cdot \text{Equity}^2 + \beta_{3;8} \cdot \text{Terms & Interactions} \]

Introduction of participating preferred term lowers the achievable firm value:
Pay-to-play and firm value

Pay-to-play term allows agents to achieve maximal firm value:

**Value-maximizing contract:**
- Convertible preferred.
- 1X liquidation.
- Pay-to-play.
- 14.7% VC equity share.

$$\log \pi = CES(i, e; \rho) + \beta_1 \cdot Equity + \beta_2 \cdot Equity^2 + \beta_{3.8} \cdot Terms & Interactions$$
VC board seats and firm value

\[ \log \pi = CES(i, e; \rho) + \beta_1 \cdot Equity + \beta_2 \cdot Equity^2 + \beta_{3:8} \cdot Terms & Interactions \]

VC board seats is nuanced:
- Increase value relative to participating preferred (offered by high quality VCs).
- Decrease value otherwise.

**Average observed contract:**
- Convertible preferred.
- 1X liquidation.
- Participating preferred.
- VC board seats.
- 39.6% VC equity share.
- Achieves **82.6%** of maximal value.
Split of value for average contract

39.6% of convertible preferred equity is 46.8% of the firm:

Slope = 1

Slope = 39.6%

Fraction of firm = 7.2%

Fraction of firm = 39.6%
Split of value for average contract

39.6% of participating convertible preferred is 49.1% of the firm:

- Slope = 1
- Slope = 39.6%
- Fraction of firm = 9.5%
- Fraction of firm = 39.6%
log(1 − α) = log(1 − Equity) + γ₁(1 − Equity) + γ₂ · Terms & Interactions

Value-maximizing contract:
- 14.7% VC equity share.
- VC retains 28.2% of firm value.

Average observed contract:
- 39.6% VC equity share.
- VC retains 49.1% of firm value.
Why the difference between average and value-maximizing contract?

- Bargaining power.
- VC is better off under the observed contract:
  - Average VC prefers 49.1% of 82.6% (best achievable in equilibrium) to 28.2% of 100%.
  - VC would like to have even more equity but is unwilling to lose entrepreneurs.
Implications for startup valuation

In practice, commonly cited measure of value is “post-money” valuation:

- Startup financed with $1m via, say, an average observable contract leaves the VC with 39.6% equity share and is “worth” $\frac{1}{0.396} = 2.53m$.

This measure is incorrect, because it assumes $Terms = \emptyset$:

- As if VC holds common equity.

Our method can value startups in the presence of other terms:

- The startup is worth $\frac{1}{0.491} = 2.04m$, or 19.3% lower than its post-money valuation, due to VC-friendly terms.
- Gornall and Strebulaev (2019) calibrate Black-Scholes valuations of unicorns in the absence of control terms and market effects.
Good VCs add firm/entrepreneur value

Although better VCs receive larger share of the firm value, entrepreneurs still prefer high-quality VCs – and their investor-friendly contracts:

However, firm and entrepreneur (but not VC) value could have been higher had VCs not been able to use their bargaining power.
Counterfactuals: contracts

Change in the present value across all deals if VC-friendly contract features (implemented by terms) are disallowed:

Entrepreneurs become more selective, while investors become less selective.
- High-quality entrepreneurs drop their worst matches and match less often.
- Low-quality entrepreneurs match more often with low-quality investors.
- At estimated parameters, the second effect dominates and leads to more frequent deals but a lower average deal value.
- **The present value of all deals modestly increases:**
  - Intuitively, the VCs can easily rebalance the remaining contract terms and achieve an almost identical outcome.

### ΔPV of Deals (% of Estimated Mkt Size)

<table>
<thead>
<tr>
<th></th>
<th>No Participation</th>
<th>No VC Board Seat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>+1.70%</td>
<td>+1.66%</td>
</tr>
<tr>
<td>VC</td>
<td>-0.20%</td>
<td>-0.35%</td>
</tr>
<tr>
<td>Entrepreneur</td>
<td>+1.90%</td>
<td>+2.00%</td>
</tr>
</tbody>
</table>
Counterfactuals: search frictions

Change in the present value of all deals if search frictions are relaxed:

- E.g., an online platform akin to AngelList is adopted:

  - VCs become comparatively more selective when cost of waiting decreases.
  - VCs offer more VC-friendly terms.
  - The frequency of deals increases but the average firm value decreases.
  - The present value of all deals can decrease if search frictions are very low.
    - This result is similar to the “Vegas effect” in Glode and Opp, 2018.
  - Entrepreneurs lose out.

### Table: ΔPV of Deals (% of Estimated Mkt Size)

<table>
<thead>
<tr>
<th></th>
<th>2X Frequency of Encounters</th>
<th>5X Frequency of Encounters</th>
<th>10X Frequency of Encounters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>+1.19%</td>
<td>-2.74%</td>
<td>-5.14%</td>
</tr>
<tr>
<td>VC</td>
<td>+2.43%</td>
<td>+5.42%</td>
<td>+7.25%</td>
</tr>
<tr>
<td>Entrepreneur</td>
<td>-1.24%</td>
<td>-8.16%</td>
<td>-12.38%</td>
</tr>
</tbody>
</table>
Caveats

Cannot speak about:

- The impact on value of contract terms that are always present:
  - They are absorbed in qualities of VC and entrepreneur.

- General equilibrium effects / extensive margin:
  - E.g., if disallow certain contractual features, would this reduce the availability of VC funding? How many VCs and entrepreneurs would enter or exit? Would VCs come up with new contractual features to substitute?
  - When participating preferred and VC board seats are disallowed, the relative present value loss to all VCs is less than 1% and gain to all entrepreneurs is approximately 4%:
    - Does entry of entrepreneurs overshadow exit of VCs?
Robustness / extensions

Results are robust to:

- Industries: IT vs healthcare.
- Deal types: seed vs Series A, syndicated vs non-syndicated.
- Time periods: before vs after Amazon Cloud, before vs after financial crisis.
- Locations: California vs Massachusetts.
- Capital intensity: low vs high.
- Outcome variables: IPO, IPO+2X M&A, follow-on financing.
- Contract filters: if two terms are present and the rest are missing, impute as zeros.
- Higher discount rate.
- Entrepreneur overconfidence.
- Higher entrepreneur bargaining power.
- Match-specific shocks (same pair of agents can sign different contracts).
- Directed search.
- Finer grid of entrepreneur and VC qualities.
- Non-optimal GMM weighting matrix.
- Endogenous investment (show via comparative statics).
Conclusions

VC quality has a positive impact on start-up and entrepreneur value:
  o Although not as high as theoretically possible.

Contracts provide a mechanism for VCs of different types to match with better entrepreneurs.
  o But VCs get a higher fraction of value than the first-best.

Contract terms have an impact on firm value and split of value:
  o For average VCs, participation and VC board seats reduce success prob. and shift value to VC.
  o For high-quality VCs, board seats actually help.
  o Pay-to-play increases value and shifts more to entrepreneur.
  o VCs get a much higher fraction of value than VC equity share alone suggests.
Empirical literature on contracts in VC market:

Empirical models of selection in VC market:

Theoretical models of contracting between entrepreneur and investor:

Theoretical models of dynamic search and matching, and matching with contracts:
Appendix: value functions

Three events can occur to VC in next time interval $dt$:

- With probability $\lambda_i dt \int_{e \in \mu_i(i)} dF_e(e)$, the VC encounters an entrepreneur in set $\mu_i(i)$ that is willing to negotiate a contract.
- With probability $\lambda_i dt \left(1 - \int_{e \in \mu_i(i)} dF_e(e)\right)$, the VC encounters an entrepreneur who is unwilling to negotiate.
- With probability $1 - \lambda_i dt$, the VC does not encounter anyone.

VC’s continuation value then is

$$V_i(i) = \frac{\lambda_i}{\lambda_i + r} \int_{e} \max\{1_{e \in \mu_i(i)} \pi_i(i, e, c^*)\}, \quad V_i(i) \int_{e} dF_e(e)$$

- Modified discount rate captures expected time until the next encounter.

Similar events and continuation value for entrepreneurs.
Appendix: dynamic vs static model

Our dynamic model of search and matching approximates reality:
  - Neither VCs nor entrepreneurs see all possible deals in the market.

Dynamic models generate exogenous variation in matches:
  - Because delay is costly, each investor (entrepreneur) matches with a range of entrepreneurs (investors).

No need to artificially split the sample into “static” subsamples.

Dynamic models are easier to estimate:
  - No need to compare observed matches and contracts to all counterfactual matches and contracts.
  - Instead, compare value of the observed match to the expected value of the next encounter.
Appendix: cumulative dividends

Cumulative dividends are supposed to increase liquidation preference by dividends $\times$ years before exit.

In practice, cumulative dividends are rarely paid.
Appendix: pay-to-play

With pay-to-play the payoff figure of convertible preferred equity can change between rounds:

![Diagram showing payoff at exit, Investment, Conversion point, and Exit value with slopes indicated for Series A and Series B (if no investment).]
# Appendix: GMM moments

<table>
<thead>
<tr>
<th>Moment</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. time since last VC financing</td>
<td>0.689</td>
<td>0.494</td>
</tr>
<tr>
<td>Var. time since last VC financing</td>
<td>1.276</td>
<td>0.420</td>
</tr>
<tr>
<td>Avg. VC share of equity</td>
<td>0.396</td>
<td>0.406</td>
</tr>
<tr>
<td>Var. VC share of equity</td>
<td>0.031</td>
<td>0.003</td>
</tr>
<tr>
<td>Skew. VC share of equity</td>
<td>0.002</td>
<td>-0.000</td>
</tr>
<tr>
<td>Cov. time since last VC financing and VC share of equity</td>
<td>0.003</td>
<td>0.001</td>
</tr>
<tr>
<td>Avg. participation</td>
<td>0.512</td>
<td>0.465</td>
</tr>
<tr>
<td>Cov. time since last VC financing and participation</td>
<td>0.055</td>
<td>0.002</td>
</tr>
<tr>
<td>Cov. VC share of equity and participation</td>
<td>0.015</td>
<td>0.018</td>
</tr>
<tr>
<td>Avg. pay-to-play</td>
<td>0.122</td>
<td>0.049</td>
</tr>
<tr>
<td>Cov. time since last VC financing and pay-to-play</td>
<td>-0.003</td>
<td>-0.001</td>
</tr>
<tr>
<td>Cov. VC share of equity and pay-to-play</td>
<td>0.012</td>
<td>-0.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Moment</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cov. participation and pay-to-play</td>
<td>0.018</td>
<td>-0.023</td>
</tr>
<tr>
<td>Avg. VC board seat</td>
<td>0.893</td>
<td>0.970</td>
</tr>
<tr>
<td>Cov. time since last VC financing and VC board seat</td>
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<td>-0.001</td>
</tr>
<tr>
<td>Cov. VC share of equity and VC board seat</td>
<td>0.006</td>
<td>0.003</td>
</tr>
<tr>
<td>Cov. participation and VC board seat</td>
<td>0.004</td>
<td>0.014</td>
</tr>
<tr>
<td>Cov. pay-to-play and VC board seat</td>
<td>0.005</td>
<td>0.000</td>
</tr>
<tr>
<td>Avg. success rate</td>
<td>0.127</td>
<td>0.093</td>
</tr>
<tr>
<td>Cov. time since last VC financing and success rate</td>
<td>-0.014</td>
<td>0.024</td>
</tr>
<tr>
<td>Cov. VC share of equity and success rate</td>
<td>0.004</td>
<td>-0.001</td>
</tr>
<tr>
<td>Cov. participation and success rate</td>
<td>-0.012</td>
<td>-0.008</td>
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<tr>
<td>Cov. pay-to-play and success rate</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Cov. VC board seat and success rate</td>
<td>0.002</td>
<td>-0.000</td>
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</tbody>
</table>
# Appendix: alternative outcomes, filters

<table>
<thead>
<tr>
<th>Outcome / contract filter</th>
<th>(1) IPO</th>
<th>(2) Followon rnd</th>
<th>(3) Imputed terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\kappa_0$ Probability of success, intercept</td>
<td>-4.072***</td>
<td>1.157</td>
<td>-6.661</td>
</tr>
<tr>
<td>$\kappa_1$ Probability of success, total value</td>
<td>0.075***</td>
<td>0.029</td>
<td>0.458</td>
</tr>
<tr>
<td>$\beta_1$ Total value, share of VC equity</td>
<td>0.682*</td>
<td>0.367</td>
<td>0.754***</td>
</tr>
<tr>
<td>$\beta_2$ Total value, share of VC equity squared</td>
<td>-2.347***</td>
<td>0.639</td>
<td>-2.692***</td>
</tr>
<tr>
<td>$\beta_3$ Total value, participation</td>
<td>-0.163***</td>
<td>0.032</td>
<td>-0.168**</td>
</tr>
<tr>
<td>$\beta_4$ Total value, pay-to-play</td>
<td>0.024</td>
<td>0.066</td>
<td>0.031</td>
</tr>
<tr>
<td>$\beta_5$ Total value, VC board seat</td>
<td>-0.026***</td>
<td>0.010</td>
<td>-0.028*</td>
</tr>
<tr>
<td>$\beta_6$ Total value, part. x pay-to-play</td>
<td>0.016</td>
<td>0.091</td>
<td>0.013</td>
</tr>
<tr>
<td>$\beta_7$ Total value, part. x VC board seat</td>
<td>0.033</td>
<td>0.032</td>
<td>0.039</td>
</tr>
<tr>
<td>$\beta_8$ Total value, pay-to-play x VC board seat</td>
<td>0.019</td>
<td>0.020</td>
<td>0.013</td>
</tr>
<tr>
<td>$\gamma_1$ Split of value, intercept</td>
<td>-0.211*</td>
<td>0.116</td>
<td>-0.215***</td>
</tr>
<tr>
<td>$\gamma_2$ Split of value, participation</td>
<td>-0.175***</td>
<td>0.054</td>
<td>-0.157*</td>
</tr>
<tr>
<td>$\gamma_3$ Split of value, pay-to-play</td>
<td>0.056</td>
<td>0.057</td>
<td>0.053*</td>
</tr>
<tr>
<td>$\gamma_4$ Split of value, VC board seat</td>
<td>-0.040***</td>
<td>0.006</td>
<td>-0.041***</td>
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<tr>
<td>$\gamma_5$ Split of value, part. x pay-to-play,</td>
<td>0.016</td>
<td>0.114</td>
<td>0.011</td>
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<tr>
<td>$\gamma_6$ Split of value, part. x VC board seat</td>
<td>0.029</td>
<td>0.054</td>
<td>0.028</td>
</tr>
<tr>
<td>$\gamma_7$ Split of value, pay-to-play x VC b’d seat</td>
<td>0.012</td>
<td>0.094</td>
<td>0.011</td>
</tr>
</tbody>
</table>
Appendix: VC and entrepreneur qualities

\[ F_i \sim Beta(a_i, b_i) \quad \text{and} \quad F_e \sim Beta(a_e, b_e) \]

Using model estimates, we can estimate sensitivities of VC and ent. qualities to observables:

- Let \( i = Y_i'\gamma_i, e = Y_e'\gamma_e \), where \((Y_i, Y_e)\) are VC and ent. observables.

- For any \((\gamma_i, \gamma_e)\), compute theoretical startup-level contracts and outcomes using model estimates.

- Estimated sensitivities \((\hat{\gamma}_i, \hat{\gamma}_e)\) minimize distance between theoretical and empirical startup-level contracts and outcomes.

- Concern: first-stage estimation error.
Appendix: qualities and firm value

\[ \log \pi = \log \text{Constant Elasticity of Substitution}(i, e; \rho) + \text{Contract} \]

Fix the contract.

Consider a startup formed by average-quality VC and entrepreneur.

A one st.dev. improvement in VC quality raises firm value by 53%:
- \[ \pi(5.20, 4.31, c)/\pi(3.49, 4.31, c) = 1.53. \]

A one st.dev. improvement in entrepreneur quality raises firm value by 29%:
- \[ \pi(3.49, 6.03, c)/\pi(3.49, 4.31, c) = 1.29. \]
Appendix: Pareto inefficient contracts

The model can produce any combination of contract terms. However, at estimated parameters, the model cannot produce contracts that combine participating preferred and pay-to-play:

- 8% of the sample.
- Reassuringly, these contracts are only slightly below the Pareto-efficient frontier (the difference between values with and without pay-to-play is small).

This observation is unimportant for method-of-moments estimation (we do not use individual observations to recover qualities).

...but implies interesting questions for future research:

- How to increase model flexibility to rationalize these contracts as efficient?
- Can these contracts really be Pareto inefficient (not all VCs are fully rational)?
Appendix: 76% of the 13.5% gap is 1X liquidation preference

At the value-maximizing contract – 14.7% VC equity, pay-to-play, 1X liquidation preference, etc. – VC receives 28.2% of total firm value.

- How to rationalize this 13.5% gap?

Consider start-up raising $1m at a $4m valuation (CP, 1X) that converts to a 15% equity.

- \( r^f = 2\% \), \( T = 5 \), no future capital needs.
  - \( \Rightarrow \) Black-Scholes value of convertible preferred is $1m, or 25% of equity.
  - Relative to 14.7%, conv. preferred is worth 25-14.7=10.3% of firm value.
  - In other words, conv. preferred explains 76% of the 13.5% gap between common equity and the value-maximizing contract.
    - Remaining gap is due to other always present terms: veto, antidilution, etc.

- Gap between common equity and convertible preferred in the average observed contract is much smaller: 7.2%.
### Appendix: some robustness tables

<table>
<thead>
<tr>
<th>Subsample/Modification</th>
<th>(1) IT</th>
<th></th>
<th>(2) Healthcare</th>
<th></th>
<th>(3) Match Shock</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ρ</td>
<td>-1.155*</td>
<td>0.094</td>
<td>-1.597***</td>
<td>0.175</td>
<td>-1.506***</td>
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<tr>
<td>β₁</td>
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<td>0.507</td>
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<td>β₃</td>
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<td>-0.147***</td>
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<td>-0.143***</td>
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<td>β₄</td>
<td>0.029</td>
<td>0.131</td>
<td>0.022</td>
<td>0.050</td>
<td>0.019**</td>
<td>0.009</td>
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<td>β₅</td>
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<td>0.009</td>
<td>-0.025***</td>
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<td>β₆</td>
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<tr>
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<td>β₈</td>
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<td>0.019</td>
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<td>γ₁</td>
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<td>-------</td>
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</table>