

VENTURE CAPITAL AND KNOWLEDGE TRANSFER

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MOTIVATION

- Innovative start-ups often produce valuable new knowledge
- Investors closely involved with the start-ups they fund (e.g. VCs) have direct access to this knowledge, unlike outsiders
- VCs can act as knowledge intermediaries, transferring knowledge between companies they fund

QUESTIONS

- When and how will VCs transfer knowledge? Costs and benefits? Implications for investment, firm performance, innovation?
- Empirical literature: positive causal impact of VC on innovation, but how? Role of knowledge transfer?
- Does form of finance affect incentives to seek patent protection?

EVIDENCE ON KNOWLEDGE TRANSFER

- Direct evidence on knowledge transfer by VCs hard to obtain, but several studies suggest it plays an important role:
- Gonzales-Uribe (2013) finds that VCs diffuse knowledge about existing, patented innovations among their portfolio companies (*reflected in higher patent citations*)
- Helmers et al.(2013) find that information transmission through interlocking boards of directors has positive effect on innovation
- Asker & Ljungqvist (2010) show that firms are disinclined to share investment banks with other firms in the same industry, but only when the firms engage in product-market competition (*suggesting concern over knowledge transfer to competitors*)
- Atanasov et al. (2007) find that 47% of a sample of VC-related lawsuits involve allegations of "tunneling".(*wrongful transfers of assets, expropriation of profitable opportunities, etc.*) Knowledge transfer typically harder to demonstrate- hence easier to undertake.

IN A NUTSHELL

- We model start-up going through ex-ante innovation stage followed by ex-post commercialization stage
- Two forms of knowledge transfer by VC:
 - ex ante, can communicate to start-up useful knowledge obtained from other firms. Helps innovation.
 - ex post, after successful innovation, can communicate innovative knowledge to other firms. Competition effect.
- We study optimal contracts between VC and start-up (endogenous knowledge transfer)

PLAN

- Baseline Model
- Non-patentable innovative knowledge: inward and outward knowledge transfer
- Patentable innovations: decision to seek patent protection
- Conclusions

TIMELINE OF THE MODEL

FIGURE: Time Line

T=0

T=1

T=2

Project funded?
Inward knowledge
transfer?

Innovation? En-
trepreneur chooses ef-
fort. Outward knowl-
edge transfer?

Project returns
realized.

THE BASELINE MODEL

- All agents (entrepreneur, investors) risk neutral; limited liability.
- Project requires initial investment I (date 0). Entrepreneur has no capital.
- During first stage, initial idea may be developed into a valuable innovation; probability π .
- If first stage successful, innovation needs to be commercialized: requires entrepreneur's effort e (key strategic decisions, new personnel recruitment...)
- Project succeeds at date 2 with probability e , yielding R (0 otherwise)

INVESTORS (1/2)

- Investors competitive, earning zero expected profits in equilibrium.
- Main difference VCs / other investors lies in VCs' *close connections* with their portfolio firms: VCs can transfer knowledge relatively easily between the firms they fund.

INVESTORS (2/2)

- **Knowledge transfer**

- *Ex-ante*, **inward** knowledge transfer ("advice"): VC communicates valuable knowledge to entrepreneur in first stage, while innovation is being developed.
Increases probability of valuable innovation to $\pi + \tau$; private cost C for VC.
- *Ex-post*, **outward** knowledge transfer ("expropriation"): VC transfers knowledge to another firm once the entrepreneur has successfully developed an innovation.
Private benefit G for VC; decreases success probability to ke , with $0 < k \leq 1$.
- Assume: entrepreneur does not observe whether the VC transfers knowledge outward; both forms of knowledge transfer cannot be contracted on explicitly.

EXPROPRIATION BY COMPETITORS

- When the VC does not expropriate the entrepreneur's innovative knowledge
 - some of his competitors may later succeed in doing so (e.g. reverse engineering)
 - or may independently develop an equivalent innovation,
- which also reduces the success probability of the entrepreneur's project from e to ke .
- We treat these two possibilities together, assuming they occur with probability $\mu > 0$.

CONTRACT DESIGN

Contracts specify the investor's (venture capitalist's) financial contribution at the beginning (I), and a sharing rule for final returns, R .

NON-PATENTABLE INNOVATIONS

- Non-VC finance: no knowledge transfer. Optimal contract max. entrepreneur's expected profits s.t. his incentive (effort) constraint and investor participation
- VC finance: 4 possible contracts (one or two forms of knowledge transfer, or none). 2 additional incentive constraints for VC: inward, and outward transfer.
- Determine: contract choice if VC; VC or non-VC?

CHOICE OF CONTRACT UNDER VC FINANCE

- ① Low cost of inward transfer ($c/\tau < I/\pi$). Then:
 - when $G > G^*$, optimal contract induces both forms of transfer
 - when $G < G^*$, only inward transfer
- ② Higher cost of inward transfer ($c/\tau > I/\pi$). then:
 - for intermediate G , optimal contract induces EITHER inward transfer OR outward transfer
 - for high G , outward transfer or both
 - for low G , inward, outward, or no transfer (no outward transfer if G very low)

INTUITION WHEN $c/\tau > I/\pi$

- For intermediate G may either
 - induce inward transfer: need high share of financial returns for VC, which deters outward transfer; or
 - induce outward transfer: need low share of financial returns for VC, which deters inward transfer thus two forms of transfer are SUBSTITUTES
- For high G they become COMPLEMENTS (provided C not too high)

CHOOSING BETWEEN VC AND NON-VC

- ① High cost of inward transfer. Then:
 - for $G < G_1$, Non-VC preferred
 - for $G > G_1$, VC preferred
- ② Low cost of inward transfer. Then:
 - either VC always preferred.
 - or non-monotonic: VC preferred for higher and lower G , Non-VC preferred for intermediate G .

INTUITION?

- Cost of VC relative to NON-VC: may either induce inefficient outward transfer, or require costly deterrence of inefficient outward transfer. This happens for intermediate G .
- Can give non-monotonicity when cost of inward transfer low because VC with (only) inward transfer optimal for low G .

PATENTABLE INNOVATIONS AND THE DECISION TO SEEK PATENT PROTECTION

We incorporate a crucial feature of the way patent systems work in practice:

- typically there is some uncertainty as to whether a patent application will be successful, even for commercially valuable innovations.
- Following development of a valuable innovation, the entrepreneur can apply for a patent: this application will be approved with probability $\beta < 1$.
- The parameter β captures the efficiency of the patent system, industry characteristics, and the characteristics of the innovation.

PATENTABLE INNOVATIONS AND THE DECISION TO SEEK PATENT PROTECTION

- If the patent application is rejected, the **leakage of information** from the patenting application increases the probability of subsequent expropriation by competitors from μ to α , with $\alpha > \mu$. Motivation: evidence from the 2008 Berkeley Patent Survey. Graham, Merges, Samuelson and Sichelman (2010) analyze the responses from 1332 early stage companies founded since 1998 and find that 35% cite "Did not want to disclose information" as a reason for not seeking patent protection for their innovations.
- If patent granted, two possibilities. Either patent used to **exclude competitors**: entrepreneur's project succeeds with probability e . Alternatively, intellectual property is **licensed**: yields revenue $L \geq G$ for the firm, while project succeeds with reduced probability ke (private knowledge transfer by the VC may yield a lower benefit than licensing, as it cannot be done through an explicit legal contract).

- Our main interest here is to explore the decision to seek patent protection, and how it differs if funding raised from VC or non-VC
- Abstract from inward knowledge transfer and focus on outward transfer: holding innovation probability π constant, will VC firms obtain more patents?

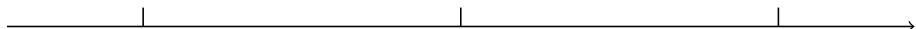
TIMELINE OF THE MODEL: PATENTABLE INNOVATIONS

FIGURE: Time Line

T=0

T=1

T=2



Project funded?

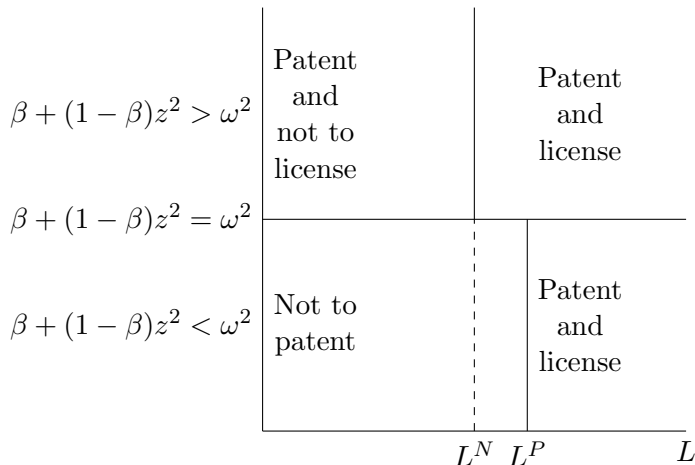
Innovation? Apply for
Patent? Granted? Li-
cense? Entrepreneur
chooses effort. If no
patent, expropriation?Project returns
realized.

THE PATENTING DECISION WITH NON-VC FINANCE

- ① If license fee $L = 0$, using patent to exclude competitors preferred, since benefit from licensing disappears, while success probability reduced by licensing. As L increases, entrepreneur's expected utility from licensing contract increases monotonically, while expected utility from the patent to exclude competitors contract unchanged. Thus for L above some threshold value, the entrepreneur's preference switches in favor of the licensing contract.
- ② Clear **trade-off** between applying for a patent with which to exclude competitors, and not applying for a patent at all. Optimal to apply for patent to exclude competitors only if expected benefit from applying for the patent (ability to **protect innovation if patent approved**), outweighs expected cost (**information disclosure**); $\beta + (1 - \beta)z^2 > \omega^2$

FIGURE 1

FIGURE: Patent and License Decision



VC INVESTOR

Entrepreneur's choice more complicated. Six possible options:

- apply for a patent, use it to exclude competitors if the patent is approved; otherwise induce the VC to transfer knowledge;
- apply for a patent, use it to exclude competitors if the patent is approved; otherwise induce the VC not to transfer knowledge;
- apply for a patent, license if the patent is approved; otherwise induce the VC to transfer knowledge;
- apply for a patent, license if the patent is approved; otherwise induce the VC not to transfer knowledge;
- do not apply for a patent; induce the VC to transfer knowledge;
- do not apply for a patent; induce the VC not to transfer knowledge.

VC INVESTOR

- But: options where VC does not transfer knowledge yield same outcome in terms of knowledge transfer as non-VC finance, and lower expected utility for the entrepreneur if the VC incentive constraint (ensuring that he does not transfer knowledge) is binding.
- Thus non-VC finance is preferred.
- Without loss of generality, can focus on three options with knowledge transfer by VC.

THE PATENT DECISION WITH VC FINANCE

LEMMA

Under VC finance always optimal to apply for patent protection

Intuition: only interested in VC finance with expropriation. When patent granted, licensing does at least as well ($L \geq G$)

LEMMA

When patent granted,

- ① If $H > G \geq C_2$, used to exclude competitors
- ② If $C_2 > G \geq H_2$, licensing
- ③ Otherwise, licensing iff $L > L^\#$

PATENTING DECISION DIFFERS DEPENDING ON FORM OF EXTERNAL FINANCE:

- it is always optimal to apply for patent protection under VC finance;
- it can be optimal not to apply for patent protection under non-VC finance, if expected benefit from applying (ability to protect innovation if patent approved) lower than expected cost (due to information disclosure)
- N.B. if we allow for inward knowledge transfer as well, for G low/intermediate may choose VC finance with (only) inward knowledge transfer; then applying for patent may not be optimal.

CONCLUSIONS

- We have explored a new rationale for VC finance: knowledge transfer.
- This can account for positive impact of VC on number of start-ups, patent applications, patents granted, and profitability.
- Important to distinguish between inward and outward knowledge transfer: different contracting implications; can be substitutes or complements.
- Potentially testable implications with data on $\mu(\alpha)$, k , G , β .