Start-Up Commercialisation Strategy and Innovative Dynamics

Joshua Gans

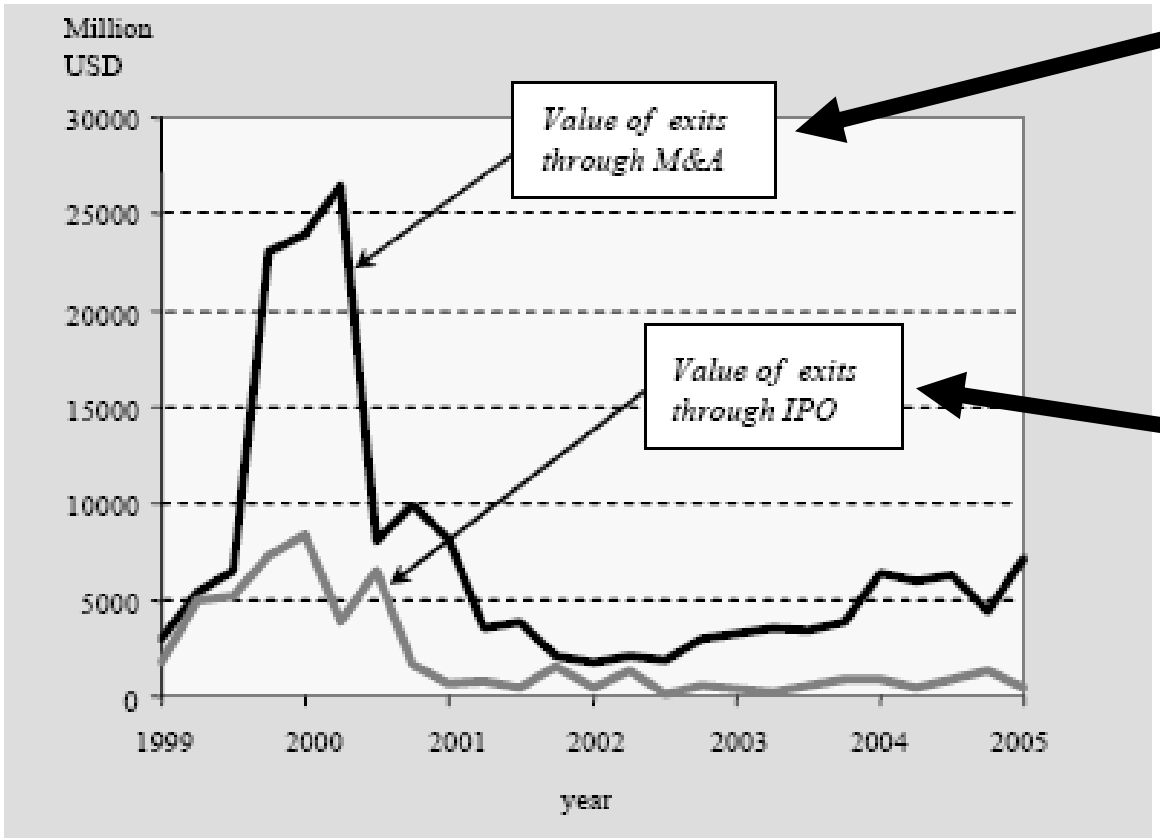
University of Melbourne

April 2007

Markets for Ideas

- Traditional models of innovation: competition
  - Start-ups innovate for entry into product markets and displace incumbents (Gilbert & Newbery, 1981; Reinganum, 1983)
- New models of innovation: cooperation
  - Start-ups have options to engage in cooperative commercialisation (e.g., licensing, acquisitions) rather than compete in product markets (Salant, 1982; Gans and Stern, 2000)
  - Advantages in saving on duplicative complementary assets (Teece, 1986) or softening of product market competition

Sources of Entrepreneurial Rents

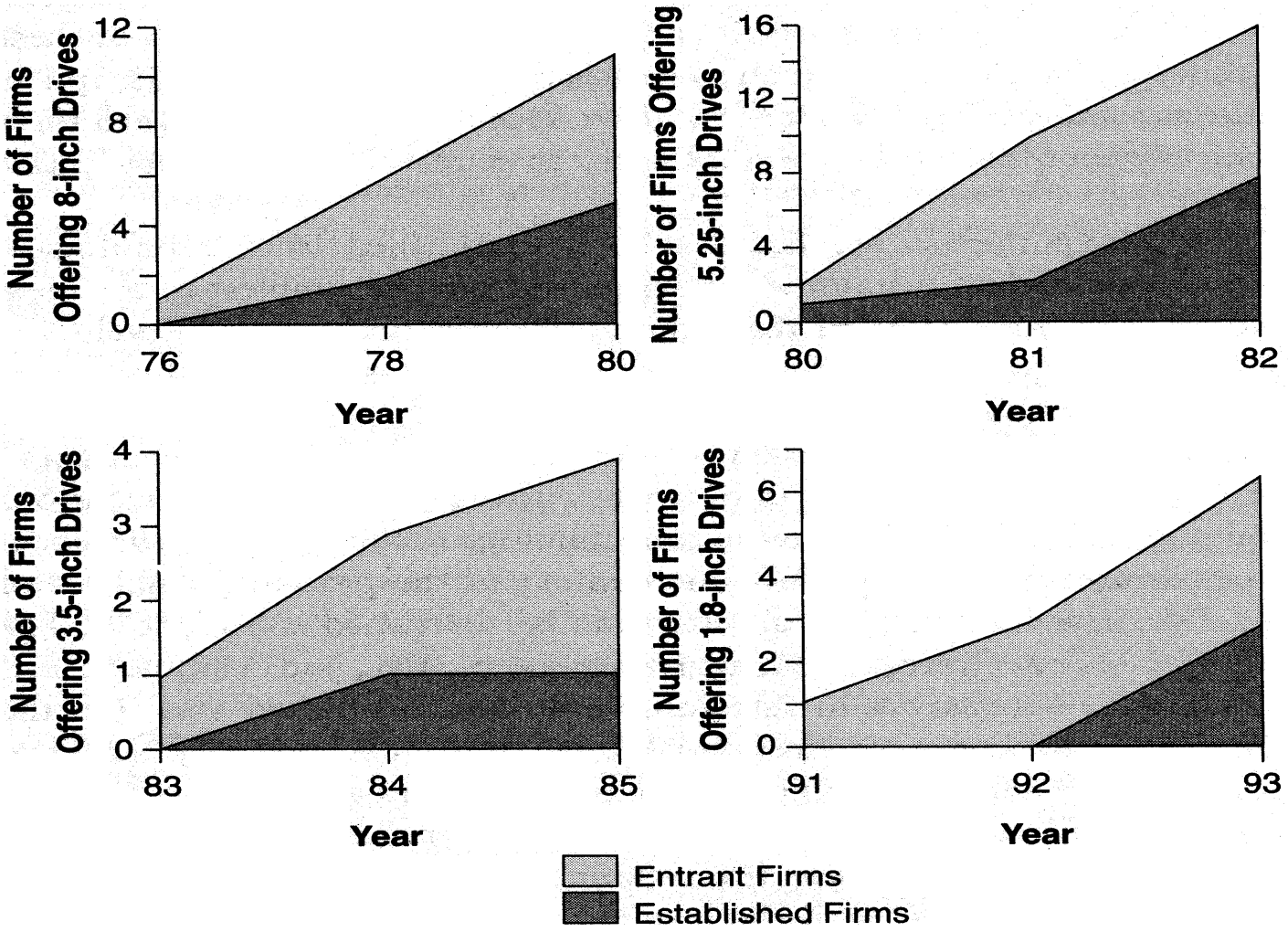


Cooperation with established firms

Competition with established firms

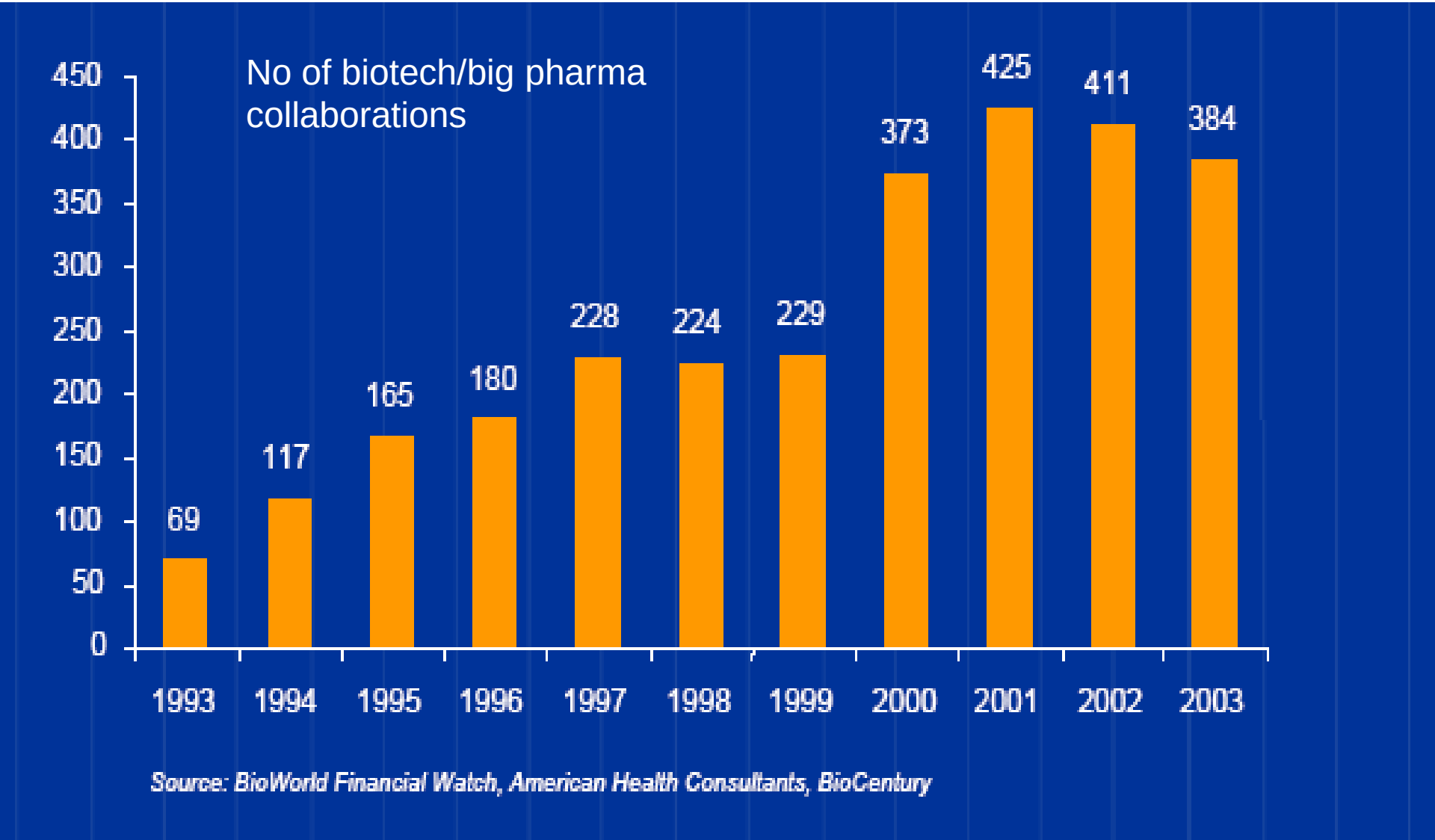
Source: Thomson Venture/NVCA

Traditional Model: Competition



(Disk Drives) Christensen, 1997, p.23

New Model: Cooperation (Biotech)



Creation without Destruction?

- **Competition**: Technological entrepreneurship can displace product market incumbents
  - Entrepreneurship implies creative destruction
- **Cooperation**: Technological entrepreneurship may reinforce existing market power
  - Entrepreneurship leads to creation but no destruction

*Key insight: Competition vs cooperation is not a given but a **choice** … the result of negotiations between start-ups and incumbents*

Our research agenda

- Part of research program with Scott Stern (Kellogg) and David Hsu (Wharton) …
- To use insights for bargaining theory to understand the commercialisation choices of start-up, entrepreneurial firms
- Two questions:
  - What are the gains from trade between start-ups and established firms?
  - What impediments exist that might prevent these gains from being realised?

Talk Outline

- Brief theoretical overview
- Empirical findings to date
  - What drives cooperative commercialisation?
  - What is the role of patent protection?
- New theoretical results
  - Licensing in a dynamic innovative environment
- Future directions

Theoretical Overview

(Bilateral) Gains from Trade

- A start-up firm and an incumbent will trade in ideas markets if their joint surplus exceeds their outside options
  - **Outside options**: If the start-up can enter the product market (or deal with another incumbent), then these are their profits under competition plus sunk entry costs (Teece, 1986)
  - **Joint surplus**: Continuation of incumbent position (plus additional value of innovation)
  - Implies **Gains from trade**: avoiding duplicative investments and softening product market competition (Gilbert & Newbery)
- Long-run: incumbent need not invest as much in R&D capabilities
  - Caveat: ability to generate substitute innovations to dampen start-up bargaining power (Gans & Stern, JEMS, 2000)

Why don't we always see ideas trading?

- **Bargaining inefficiency**
  - Information asymmetries cause inefficient break-downs or delay – however, we will see attempted trading.
- **No gains from trade**
  - There are incomplete contracts implying that continued start-up ownership and control is important. For example, to facilitate transfer of tacit knowledge (Arora, 1995)
- **Strategic bypass**
  - Negotiations may require disclosures that harm the start-up's competitive position (i.e., allowing incumbent imitation); so much so that they avoid the negotiation option – Arrow's **disclosure problem** (Anton-Yao, 1994)

Disclosure problems

- Arrow (1962): if need to sell ideas then buyers have an issue of evaluating quality or alternatively will expropriate sellers
  - Causes low returns
- Overcome this by:
  - Competing buyers (Anton and Yao, 1994)
  - Partial disclosure (Anton and Yao, 2003) or payment (Arora, 1995)
  - Venture capital networks (Hsu, 2005)
  - Relational contracting (Gans and Stern, 2003)
  - Strong IP protection (Gans, Hsu and Stern, 2002)

Drivers of cooperative commercialisation

Competitive Dynamics Are A *Consequence* of the Commercialisation Environment

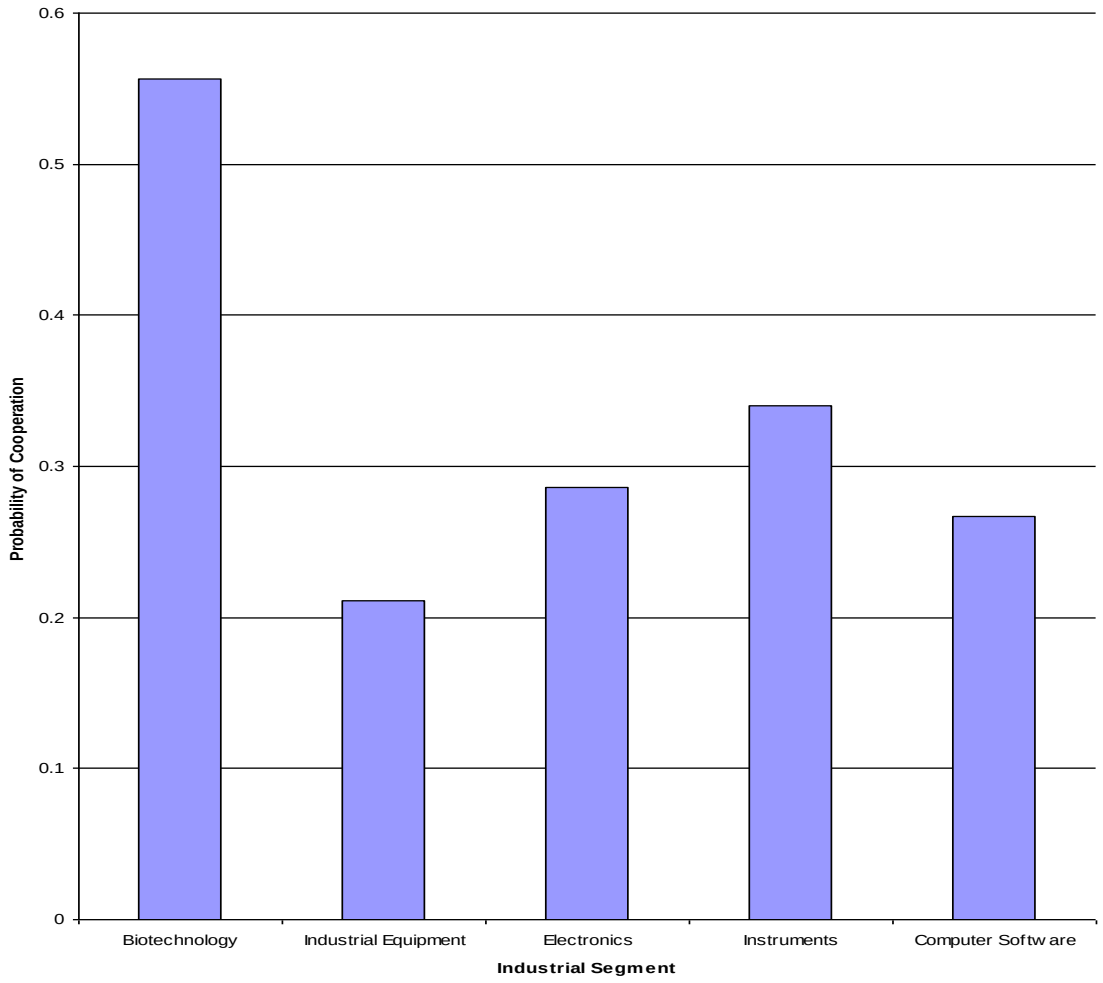
		Do incumbent's complementary assets contribute to value proposition from new technology?	
		No	Yes
Can invention by the start-up preclude effective development by the incumbent?	No	The Attacker's Advantage	Reputation-based ideas trading
	Yes	Greenfield Competition	Ideas Factories

Empirical Goals

- What factors drive the choice of commercialisation strategy by start-ups?
- What is the link between these and the operation of markets for ideas?
- Do well-functioning ideas markets enhance entrepreneurial innovation?

Inter-industry Variation

Figure 1: Probability of Cooperation by Industrial Segment
(from Gans, Hsu and Stern, 2002)



Differences in Commercialization Strategy Across Industry Result from Differences in the Commercialisation Environment

		Do incumbent's complementary assets contribute to value proposition from new technology?	
		No	Yes
Can invention by the start-up preclude effective development by the incumbent?	No	Disk Drives	Cisco
	Yes	Video Games	Biotechnology

When Does Start-Up Innovation Spur the Gale of Creative Destruction? (GHS, 2002)

		Do incumbent's complementary assets contribute to value proposition from new technology?	
		No	Yes
Can invention by the start-up preclude effective development by the incumbent?	No	14%	30%
	Yes	34%	56%

Based on a sample of 118 start-up innovators across 5 industry segments.

When Does Start-Up Innovation Spur the Gale of Creative Destruction? (GHS, 2002)

		Importance of complementary assets held by incumbents	
		Low	High
Ability to use intellectual property rights protection	Low	14%	30%
	High	34%	56%

Based on a sample of 118 start-up innovators across 5 industry segments.

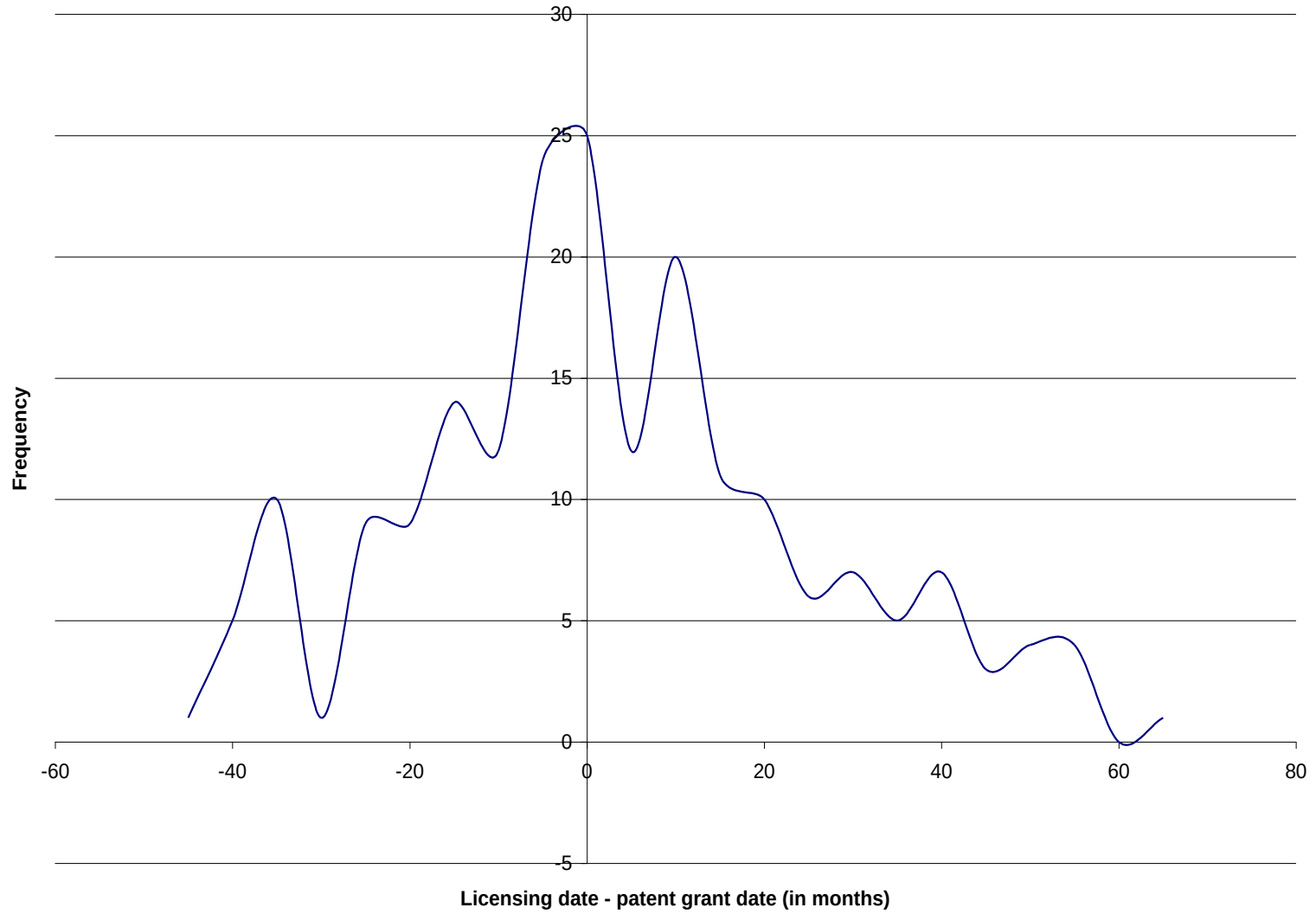
Role of VCs

- Gans, Hsu, Stern (2002): compared VC backed and government funded start-ups and showed that VC funding was positively correlated with cooperative commercialisation
- Hsu (MS, 2004): in a broader sample, confirmed this correlation and also added the likelihood of an IPO
- Take-away: VCs keeps the entrepreneurs honest.

How does IP protection work?

- Does IP protection actually facilitate ideas trading? Or are industries which have lots of IP protection associated with environments more conducive to ideas trading (e.g., by providing easy to evaluate and contract, product standards)?
- Gans, Hsu, Stern (2006): We exploit a fundamental (though often ignored) feature of the patent system – ***patent grant delay*** – in order to better understand the role of the IP system on the function of the market for ideas
- Bargaining theory:
  - Absent any frictions, patent grant date does not impact upon the timing of technology licensing
  - Some frictions mean that the gains from trade from licensing is actually maximised at the patent grant date: information asymmetries (about patent scope), search and tacit knowledge transfer costs (incentives to find appropriate partner or transfer tacit knowledge may be highest with patent uncertainty resolved).
- Empirical hypothesis: if patent grant date matters in the timing of technology licensing this (a) indicates the presence of frictions; (b) that patent resolves those frictions.

Patent/Licensing Lags



Gans, Hsu and Stern (2006)

- Some facts
  - Both pre- and post-patent licensing possible in equilibrium (40% of our sample of licenses are achieved pre-patent grant)
  - While 50% of licenses (in our sample) are achieved pre-grant, the assignment of IPR raises the licensing *hazard rate* by at least 50%
- The impact of patent grant on the timing of cooperation depends on characteristics of the firm and its environment
  - Patent grant matters less when alternative institutions exist (Silicon Valley– networks; SW -- copyright)
  - Patent grant matters less when technology cycle times are short (knowledge obsolescence)

Licensing in a dynamic innovative environment

Dynamics and Ideas Markets

- Static rationale for cooperative commercialisation is strong
- Informal strategic concern (esp in teaching cases):
  - EMI & the CT Scanner: "licensing would be … 'selling our birthright.'"
  - Nucleon: licensing was viewed as 'mortgaging away' the company's future.
  - Ecton: "Cannon was also concerned about the impact that an acquisition might have on Ecton's product development process…. The Ecton founders were worried that if their company were absorbed into a larger organization after acquisition, their development efforts for next-generation products would get mired … Perhaps, they reasoned, their efforts would be more successful in the long run if they remained independent until they had a refined product development process that might survive acquisition and integration."
- Informal economic reaction:
  - No problem. Then, start-up should build future losses into the 'price'
- Formal evaluation
  - Requires a dynamic model of successive innovation

Technological Dynamics

- Most models of innovation and ideas markets are static
  - Roles of firms in an industry is fixed
  - Single innovation race
- Dynamics – on-going innovation races
  - Entrants come in and may become incumbents
  - Incumbents protect against entrants
  - Licensing may preserve roles in equilibrium but not off the equilibrium path

Segal-Whinston (AER, forth)

- Model of dynamic technological competition
  - SW apply to antitrust practices
  - SW consider entrants as competing and displacing incumbents – on-going change
- Here, two modifications
  - Incorporate ideas markets
  - Allow for multiple innovators
  - Model dynamic capabilities (firms may not be long-lived)

Model Set-Up

- Technology
  - Sequential innovations – new product generations displacing old
  - Old generations provide competitive discipline
- Innovator selection
  - Innovator with the capability to invest towards the next generation is selected from a pool comprising an infinite number of potential start ups and also the firms active in the market for the previous generation.
  - If a start-up is selected, it becomes the entrant (*E*). It chooses ϕ_E (the probability of innovating in the current period) at a cost, $c(\phi_E)$.
  - If current incumbent is selected, there is no entry. The incumbent chooses ϕ_I (the probability of innovating in the current period) at a cost, $c(\phi_I)$.
- Firms
  - Incumbent (*I*) current patent holder of leading tech generation and has advantage in commercialising next gen. Earns per period profits of Π and a 'bump' to those profits of Δ if it innovates.
  - Common discount rate is δ
  - If it innovates, to compete, *E* needs to sink costs (*f*) and earns π before getting Π thereafter (then *E* becomes the incumbent and has an advantage in commercialising the next generation).
  - The incumbent's profits are reduced to π (for the current period) but commercialisation advantage transfers to the entrant (who is relabeled *I*).
  - Assume that entry is credible ($\pi > f$) and that $2\pi < \Pi$.

Commercialisation Options

- If it innovates, *E* has to option to give *I* an exclusive license and commit not to compete.
  - Modeled using Nash bargaining over τ, the once-off payment to *E*.
  - *E* returns to the pool of potential innovators for the next generation while *I* remains the incumbent and preserves advantages.
- If *E* chooses to compete, then it becomes the incumbent (*I*) for the next generation
  - Both return to the pool of potential innovators and may become the next innovator.

Dynamic Capabilities

- What happens to a displaced incumbent or paid-off entrant
  - Static models: assume exits
  - SW: incumbent takes on the entrant role for the next generation
- Parameterise this:
  - σ_p is the probability that a displaced incumbent becomes the entrant. If not, a new firm enters.
  - σ_i is the probability that an entrant who licenses continues as the entrant. If not, a new firm enters.
  - σ_{ip} is the probability that an incumbent who has produced and innovated in the previous period, becomes the innovator. If not, a new firm enters.
- Higher probability implies a stronger dynamic capability (ability to transition between technological generations) – see Teece, Pisano and Shuen (1997)

No Licensing Case

- Continuation Payoffs

$$V_I = (1-\phi_E)(\Pi + \delta V_I) + \phi_E(\pi + \sigma_p \delta V_E)$$

$$V_I^i = (1-\phi_I)(\Pi + \delta V_I^i) + \phi_I(\Pi + \Delta + \sigma_{ip}\delta V_I^i + (1-\sigma_{ip})\delta V_I) - c(\phi_I)$$

$$V_E = (1-\phi_E)\delta V_E + \phi_E(\pi - f + \sigma_i \delta V_I^i + (1-\sigma_i)\delta V_I) - c(\phi_E)$$

Equilibrium

Decompose innovation choice:

- Innovation prize (IB)

$$W_E = \pi - f + \delta\left(\sigma_i V_I^i + (1-\sigma_i)V_I - V_E\right)$$

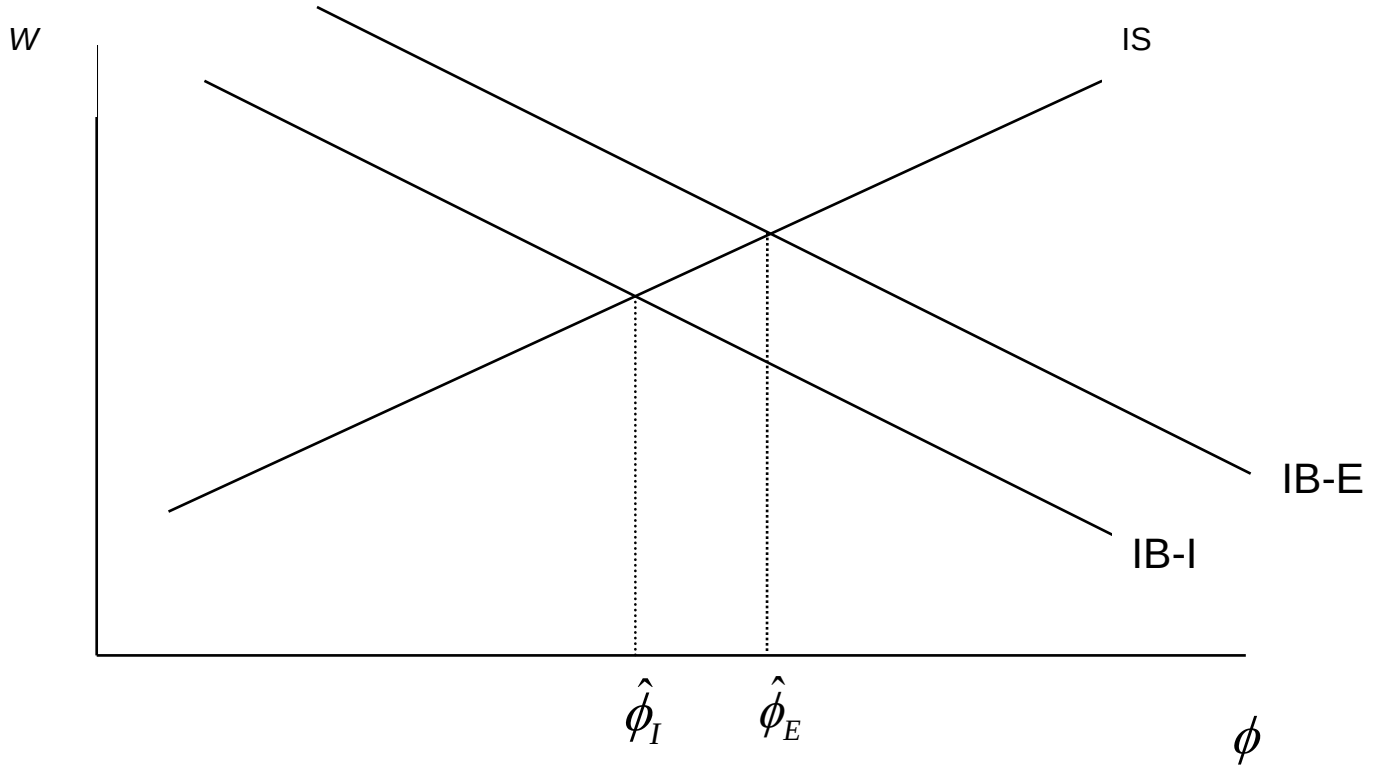
$$W_I = \Delta - (1-\sigma_{ip})\delta\left(V_I^i - V_I\right)$$

- Innovation supply (IS)

$$\phi \in \arg\max_{\varphi\in[0,1]} \left\{\varphi W - c(\varphi)\right\}$$

Equilibrium under Competition

Figure One: Equilibrium under Competition



Comparative Statics

- In a Markov perfect equilibrium, the rate of innovation is increasing in σ_p
- The more likely *I* will persist in the industry, the higher is V_I.
  - So long as $V_E > 0$, this possibility only adds to incumbent value
  - The profits of both *I* and *E* are discounted by their likelihood of persisting (raising V_E as well)
  - Thus, increasing σ_p unambiguously raises the incumbency advantage ($V_I - V_E$); a shift in the IB curve.
- If *I* invests in capability, will want to do so even though it would prefer a slower innovation rate.

Commercialisation Options

- Licensing
  - Start-up licenses to the incumbent and then rejoins the pool of potential innovators
- Acquisition
  - Start-up is acquired by the incumbent and the incumbent has both innovative and productive capabilities

Gains from Trade

	E	I
Compete	$\pi - f + \sigma_i \delta V_I^i$ $+(1-\sigma_i)\delta V_I$	$\pi + \sigma_p \delta V_E$
Integrate	price	$\Pi - \text{price} + \sigma_{pi} \delta V_I^i$ $+(1-\sigma_{ip})\delta V_I$
Sell-Out	$\tau + \sigma_i \delta V_E$	$\Pi - \tau + \sigma_p \delta V_I^i$ $+(1-\sigma_p)\delta V_I$

Licensing Case

- Gains from trade from licensing if:

$$\underbrace{\Pi - \tau + \sigma_p \delta V_I^i + (1-\sigma_p)\delta V_I + \tau + \sigma_i \delta V_E}_{\text{Joint Payoff from Cooperation}}$$

$$\geq \underbrace{\pi + \sigma_p \delta V_E + \pi - f + \sigma_i \delta V_I^i + (1-\sigma_i)\delta V_I}_{\text{Joint Payoff from Competition}}$$

$$\Pi - (2\pi - f) \geq \left(\sigma_i - \sigma_p\right)\delta\left(V_I^i - V_E - V_I\right)$$

$$V_E > V_I^i - V_I$$

Licensing Case

- If $\sigma_i < \sigma_p$, may not be positive
  - E.g.: $\sigma_i = 0$, $\sigma_p = 1$; then neither party earns δV_E by signing a licensing agreement; this confers a positive externality on a third party
  - If $\delta V_E > \Pi - 2\pi + f$; overall gain will not be positive
- V_E is endogenous so need to solve for it under licensing
  - Use the Nash bargaining solution (E bargaining power of γ)

$$\tau = \Pi\gamma + (2\pi - f)(1-\gamma) + \delta(V_I - (\sigma_E(1-\gamma) + \sigma_I\gamma)V_E)$$

Licensing Case

- Continuation Payoffs

$$V_I = \Pi + \delta V_I + \phi_E \left(\tau + \sigma_p \delta \left(V_I^i - \delta V_I \right) \right)$$

$$V_I^i = (1-\phi_I)(\Pi + \delta V_I^i) + \phi_I (\Pi + \Delta + \sigma_{ip} \delta V_I^i + (1-\sigma_{ip}) \delta V_I) - c(\phi_I)$$

$$V_E = (1-\phi_E) \delta V_E + \phi_E (\tau + \sigma_i \delta V_E) - c(\phi_E)$$

Equilibrium

Decompose innovation choice:

- Innovation prize (IB)

$$W_E = \tau - (1-\sigma_i)\delta V_E$$

$$W_I = \Delta - (1-\sigma_{ip})\delta\left(V_I^i - V_I\right)$$

- Innovation supply (IS)

$$\phi \in \arg\max_{\varphi\in[0,1]} \left\{\varphi W - c(\varphi)\right\}$$

Will Licensing Occur?

- Proposition 1: Licensing is an equilibrium outcome if:
  - (i) $\sigma_i \geq \sigma_p$
  - (ii) δ is sufficiently small
  - As $\sigma_p - \sigma_i$ and δ each approach 1, licensing is not an equilibrium outcome and competition occurs.
- Licensing is not an equilibrium when expected entrant profits are high but the probability that the current entrant remains is low
  - Not so much the value of the birthright being high for *E* but for a new player.
- Bargaining power: as γ approaches 1, $V_I > 0$
  - Prior to innovation, the incumbent captures monopoly rents, so observationally is cash flow positive
  - However, more profitable to be *E* than *I*

Acquisition

- Gains from trade

$$\underbrace{\Pi - \tau + \sigma_{pi}\delta V_I^i + (1-\sigma_{ip})\delta V_I + \tau}_{\text{Joint Payoff from Cooperation}}$$

$$\geq \underbrace{\pi + \sigma_p \delta V_E + \pi - f + \sigma_i \delta V_I^i + (1-\sigma_i)\delta V_I}_{\text{Joint Payoff from Competition}}$$

$$\Pi - (2\pi - f) \geq \sigma_p \delta V_E - (\sigma_{ip} - \sigma_i)\delta(V_I^i - V_I)$$

Licensing vs Acquisition

- Acquisition is preferred to licensing if:

$$(\sigma_{ip} - \sigma_p)(V_I^i - V_I) \geq \sigma_i V_E$$

Impact of Licensing on Innovation

- Suppose that $\sigma_p = \sigma_i$ (licensing an equilibrium)
- Immediate Consequence (more rents for *E* with licensing):
  - No Licensing: $\pi - f$
  - Licensing: $\Pi\gamma + (1 - \gamma)(2\pi - f)$
- Future Benefits (less rents for *E* with licensing):
  - Under both, the innovator appropriates the rents associated with an incumbency advantage
  - Under licensing, the incumbency advantage may be lower because V_E is higher
- Proposition 2: The immediate consequence (which is certain) outweighs any potential loss of incumbency advantage (which is prospective) so licensing results in a higher innovation rate

Capabilities and Innovation

- Competition: innovation rose with σ_p
- Cooperation: innovation falls with σ_p
  - Higher σ_p increases V_I but reduces gains to trade from licensing as I's outside option is improved
  - Lower license fee and hence lower innovation
- Endogenous licensing
  - U-shaped relationship
  - For low σ_p, there is cooperation and innovation falls as σ_p rises
  - At some σ_p, switch to competition and the reverse occurs
- For entrant capabilities
  - Increase in σ_i, increases innovation

Extensions

- More innovative entrants:
  - By adding more innovators, the innovative capacity of the industry rises and with it the innovation rate.
  - What happens to the gains from trade from licensing?
    - Any given firm has a reduced chance of winning an innovation race so V_E falls
    - But capabilities may improve chances of winning next innovation race.
    - No clear comparative static
- Innovative incumbent:
  - Improves V_I but will also spur innovation under competition
  - But V_I does not enter into the gains from trade equation so there is no change in the likelihood of licensing conditional on entrant innovation

Future Research

- IP practices
  - Impact of cumulative innovation
  - Minimum inventive step
  - Disclosure requirements
  - Experimental use
  - Protection from expropriation
- Strength of IP (may reduce innovation)
- Role of bargaining on scientific/academic innovation