"Moving Ideas from Lab to Market"

Economics of University Technology Transfer: Key Findings and Policy Issues

Mark Schankerman
London School of Economics and CEPR

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Universities are an important source of innovation

- 50% of basic research in the United States. In Japan, 52% in 2011
- Dramatic increase in university technology transfer in the U.S.
  - patents awarded to U.S. universities: 500 in 1982, 3,100 in 1998 and 5,145 in 2012
  - number of new licenses: 1278 in 1991 and 5,130 in 2012
  - total income (including royalties and cashed-in equity value) in real terms: $186 million in 1991 and $1.54 billion in 2012

University research generates “real” economic effects

- Stimulates R&D by “local” firms by raising the marginal productivity of their R&D (“knowledge spillovers”). More on the localised spillovers later.
- Increases patenting by “local” firms, controlling for the level of their R&D
- Increases patenting, licensing and new start-up companies by universities

U.S. Institutional background

Bayh-Dole Act, 1980: This gave universities and research institutes ownership of inventions from federally funded R&D, with mandate to undertake technology transfer and to share revenues with university inventors

Before this, universities required bilateral approval with all federal funding agencies.

BUT Bayh-Dole Act did not give birth to technology transfer

Technology licensing occurred before Bayh-Dole, through bilateral arrangements with government agencies. But transactions cost and uncertainty were higher. (David Mowery and others)

Much technology transfer is biomedical-related, which was triggered by the biotechnology revolution rather than Bayh-Dole

It is virtually impossible to determine how much of the growth in technology transfer activity is due to the Bayh-Dole Act. This is not a useful pursuit.

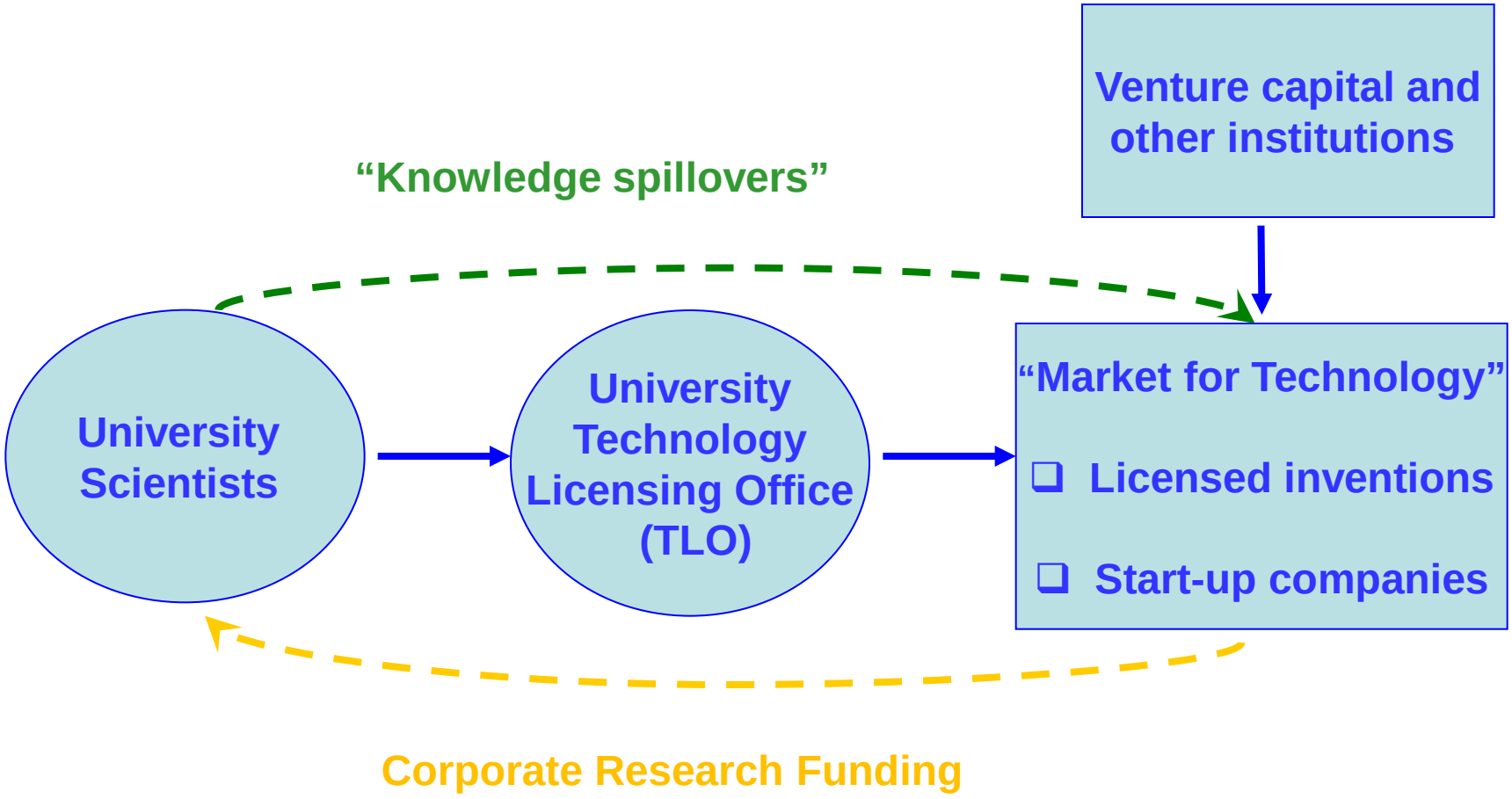
Instead, I want to discuss:

1. What are the benefits and costs of such technology transfer?

2. What are the instruments and institutional arrangements that most effectively incentivize and facilitate? How should we organise the “market for technology transfer”?

In particular, what is the role for incentives and competition in university research activity and licensing, and what are the other key features of the relevant “innovation ecosystem” that facilitate technology transfer?

University-Private Sector Science Links



Important to distinguish between technology transfer and contract (corporate-sponsored) research. The economic benefits and costs differ.

Potential Benefits

1. Social gains from ensuring *"efficient delegation"* in commercialisation of university inventions
   - Monetary incentives for universities to exert effort to license early-stage technologies to existing firms or start-ups
   - Clarity of property rights facilitates this process (as it increases the willingness of licensees to contract)

2. Increased incentives for research scientists to focus on commercially relevant technologies (but may be a potential cost)

3. Supplementary income source for universities
   - Returns highly skewed over time and across universities
   - Most TLO's appear to lose money. But what should we infer from this (apparent) fact?

Potential Costs

1. Tilting focus from basic to applied research
   - To what extent can university scientists really substitute? What about other incentives, such as getting tenure?
   - Are these two types of research really substitutes or complements?
   - What is the appropriate mix of basic and applied research in universities, as opposed to companies?

2. Restricting ‘open science’
   - Increased delays in publishing research findings
   - Increased delays or refusals to engage in material transfer agreements, and other transaction costs from IP rights
   - Potential conflict of interests in university research

What does the evidence say?

1.No evidence that patenting replaces publications

- Survey of MIT scientists shows no (self-reported) shifting from publications to patenting, especially quality-adjusted) [Agrawal and Henderson, 2002]

- Econometric research shows patenting and publications are complements not substitutes [Azoulay et al, 2007]. We will see why.

2. Limited impact on choice of research and information sharing

- Surveys (two rounds) of biomedical researchers in universities and companies show **no major** delays/abandonment of projects due to transaction costs arising from property rights [Walsh, Aurora and Cohen]

- But what about projects that were not undertaken? Some evidence of obstacles/delays in getting MTA's for research purposes.

- Research exemption may be an important element here, which needs to be enforced

3. Patenting and publishing are complements, not substitutes, for most academic scientists, certainly for star scientists.

   - Patenting is often associated with a flurry of scientific publications by the same inventors. Patents may indicate research success rather than a retreat from fundamental research.

   Another reason for limited negative effects may be that much research is “dual purpose”, as illustrated by the following diagram.

Quadrants of Scientific Research

Search for Fundamental Understanding	Considerations of Use: No	Considerations of Use: Yes
Yes	Pure basic research (Bohr)	Use-inspired basic research (Pasteur)
No		Pure applied research (Edison)

Incentives and Institutions to Facilitate University Technology Transfer

Central Points of the Presentation:

1. Performance-based (“high-powered”) incentives for inventors matter greatly

2. High-powered incentives for TLO’s improve licensing performance

3. Local development objectives for TLO’s are expensive and alternative means to finance local development may be desirable

4. Incentives for inventors and effectiveness of technology licensing offices are complementary. Policies need to address both together.

5. Rethinking the institutional organisation of technology licensing activity is a key challenge for scholars/policy-makers.

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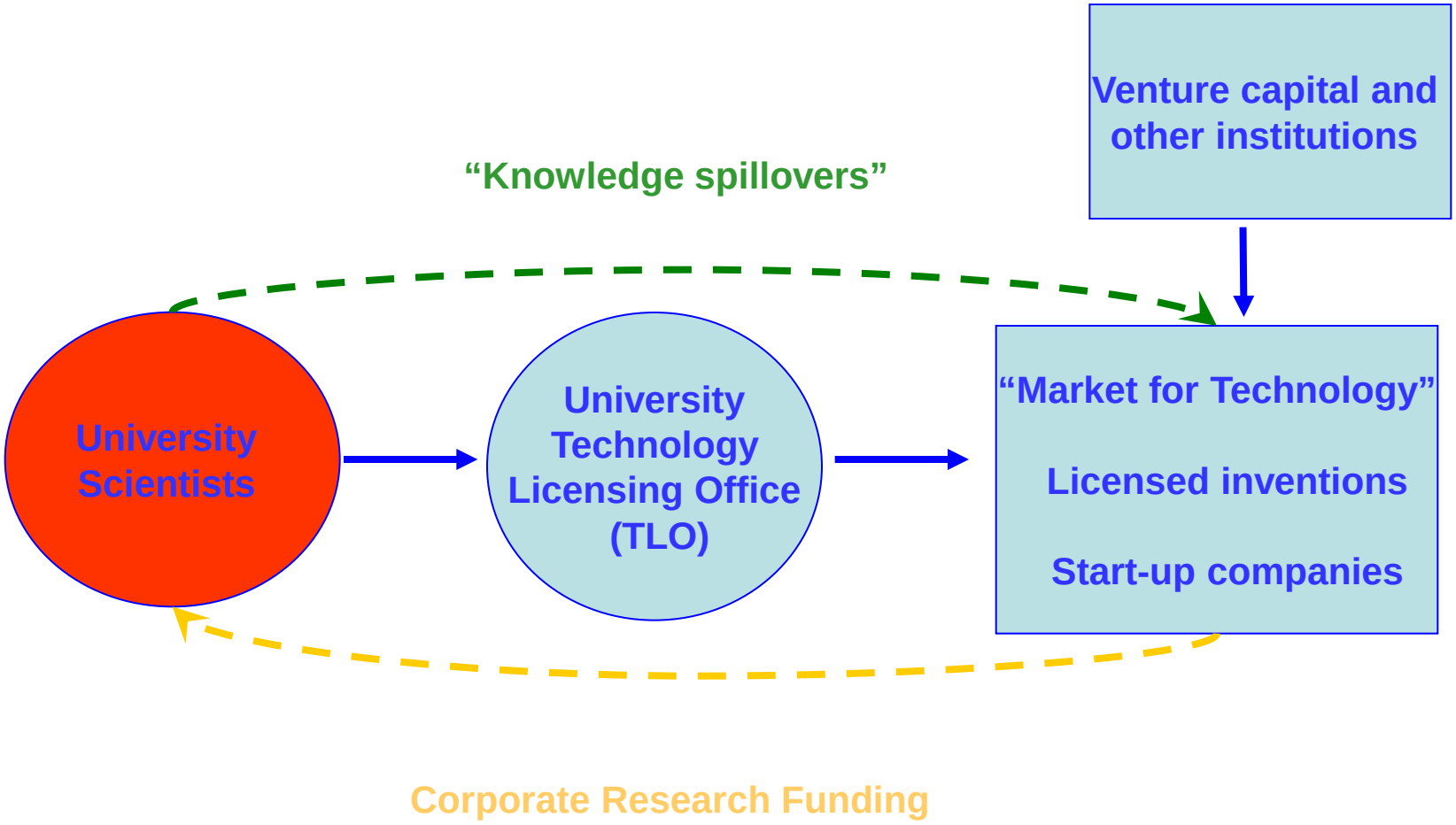

Issue 1. Do monetary incentives affect university innovation and technology transfer performance?

[Lach and Schankerman, 2008]

First, technology transfer 'performance' has multiple dimensions:

- number of licenses (form too, exclusive versus non-exclusive)
- licensing revenue per license
- number of start ups (though why focus on them versus licensing to existing firms)?

Ultimately we care about welfare impact of tech transfer but that is virtually impossible to measure.

The L-S "experiment" exploits variation across U.S. universities in (ex ante) royalty sharing to identify its impact on performance. Focus on number of inventions (disclosed to the TLO) and license revenue.

- **Inventor royalty share:** "control rights" definition of inventor share (cash to inventor or direct rights over it)
  - All universities publish their royalty schedules on their websites (they change periodically). They are part of the faculty employment contract.
  - Royalty sharing divides revenues received by the university between the inventor, lab, department, university.

- **Three key characteristics of inventor royalty shares**:
  1. Very large variation across universities
  2. Observe both linear and non-linear royalty schedules
  3. Non-linear sharing is always regressive (lower inventor shares for higher levels of license income)

Table 1

Inventor Royalty Shares in U.S. Universities

	Mean	Min	Max
Linear (n=58)	41	21	65
Non-linear (n=44)	51	20	97
Income interval:			
<10,000	53	20	100
10,000-50,000	45	20	93
50,000-100,000	42	20	85
100,000-300,000	35	20	85
300,000-500,000	33	20	85
500,000-1 million	32	20	85
>1 million	30	15	85

Summary of main findings

1. Inventor royalty shares strongly affect license income. A 10 percentage point increase in inventor share raises income by 19%, on average. In private universities, by 50%.

- Distinguish cash flow rights (division of money) from ownership rights (decision-making authority about use of the invention). No research to date on whether assignment of ownership rights ('professor privilege') matters.

2. Impact of incentives is larger in private than public universities. Why? Points to the importance of institutional arrangements within TLO's .

3. Incentives raise both **quantity** and **quality** (income/license) of licenses

4. Incentives work through two channels: increase scientist **'effort'** and induce **'sorting'** of scientists among universities

Endogeneity Issues: Is it really incentives?

1. **Unobserved quality differences**: Some universities are higher quality and thus earn more license income. If they also adopt stronger incentives, we might think it is incentives when it is really just quality.
   - We control for academic quality, and still find an incentive effect.
   - Adoption of stronger royalty incentives is not correlated with any observable university characteristics (including quality, size etc).
   - We also control for patenting behaviour before our sample period to capture 'quality' differences. The incentive effects is robust.

1. **Reverse causality**: Universities with bad performance may adopt higher inventor royalty shares. This would make us understate the true effect of incentives.

Why is the impact of royalty incentives different for public and private universities? If a Berkeley scientist moves to Stanford, why should incentives be more effective?

Gatekeeper Effect: The impact of royalty incentives depends on the effectiveness of TLO

- If a TLO is ineffective (many scientists complain about them) and has monopoly power over commercialisation, changing incentives will not have much effect. Thus royalty incentives and TLO effectiveness are **complementary policy instruments**.

- Emphasises importance of institutional structure: Should the university TLO have sole control over licensing of university inventions?

- But why should we expect private university TLO's to be more effective? Is there any evidence of this difference and what accounts for it?

Evidence from a new survey of university technology licensing offices indicates that private universities are likely to be more effective than public ones for three reasons:

1. Private universities are more likely to use performance-based incentives for their TLO staff

2. Private universities are less likely to be constrained by government in their licensing activities

3. Private universities are typically less focused on “local and regional development” goals

Survey Evidence: Incentives, Constraints and Objectives in TLO's

	Public	Private	Significant Difference?
Faculty Awareness of Incentives (% yes)	91.7	96.4	No
University Rewards Tech transfer (% yes)	9.4	15.4	No
Use of Incentive-pay (% yes)	49.0	79.0	Yes
Government constraints on (% "important" or "very important"):			
1. Choice of license partners	23	0	Yes
2. Setting license contract terms	19	0	Yes
3. License confidentiality	27	0	Yes
4. Use of equity stakes	23	4	Yes
5. University liability/indemnification	75	18	Yes
6. Dispute resolution mechanisms	49	4	Yes
Objectives (% "important or very important")			
1 Number of licenses	97	100	No
2. License income	88	93	No
3 Promoting local/regional development	88	57	Yes

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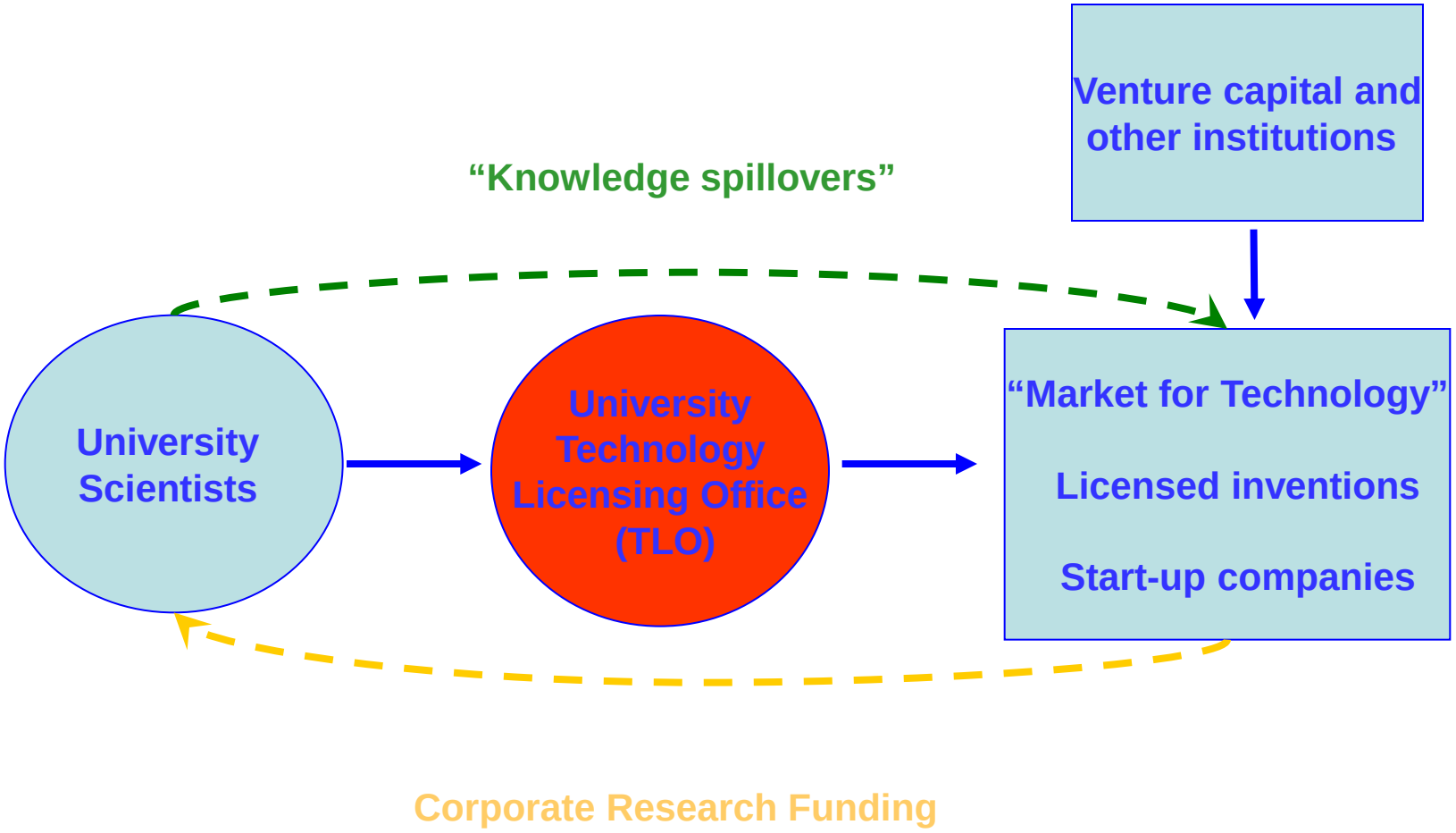

Issue 2: How TLO Incentives, Local Development Focus and Government Constraints Affect TLO Performance

[Belenzon and Schankerman, 2009]

How is university technology transfer performance affected by:

1. whether university TLO's use performance-based pay for its professional staff

2. importance of local development objectives in the TLO

3. importance of government constraints on licensing by the TLO

Which Types of Universities Use High-Powered Incentives?

Relationship between Adoption of Incentives and University Characteristics

Variable	*Public*	*Private*	*LOCDEV = Low*	*LOCDEV = High*	*Not-Constrained*	*Constrained*	*Low Techpole*	*High Techpole*
Probabilty No inecntives	0.50	0.21	0.42	0.41	0.35	0.65	0.48	0.29
Probabilty Merit Pay	0.35	0.54	0.37	0.48	0.45	0.25	0.42	0.39
Probabilty Bonus Pay	0.15	0.25	0.21	0.10	0.20	0.10	0.10	0.32

Empirical Predictions

	License income	Number of licenses	Total startups	Local startups
Performance-Based Pay	Positive	Positive	Zero	Zero
Local Objectives	Negative	Positive	Zero	Positive
Constraints	Negative	Zero	Negative	Zero

Key Findings: Income per License

1.Using performance pay raises income/license by 30-45%

2.Strong local development objectives reduce income/license by 30%

Adopting a local development bias in university licensing policy has a large implicit “cost” – making less money. Do the ‘local multiplier’ effects, or other benefits, make this licensing policy worthwhile?

3. Strong government constraints reduce income/license by 25%

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Key Findings: Number of Licenses

1. Performance pay does not affect the number of licenses per invention. Why? Because numbers are easier to monitor by managers than income per license ("what might have been").

2. Strong local development objectives are associated with 30% more licenses per invention.

3. Strong government constraints have no significant effect on the number of licenses per invention.

Key Findings: Number of Start-ups

1. Performance-based pay and local development bias do not affect the number of start ups per license executed – i.e., the licensing mode.

2. But strong local development objectives strongly affect the likelihood that the licensed start-ups are located within-state.

3. Private universities are less likely to license start-ups than public universities. May have to do with the metrics used (by state government) to evaluate performance, so the choice is important.

Issue 3. Are university knowledge spillovers localised? How does a strong local development bias affect this?

[Belenzon and Schankerman, 2013]

1. University knowledge spillovers are strongly localised
   - Citation to patents declines sharply with distance (flat after 150 miles)
   - Citation much more likely if from an inventor located in the same state

2. 'Border effect' is much larger for public universities than private ones
   - Accounts for about 25% of the mean citation rate for public, but only 6% for private universities. Why?

3. Stronger local development objectives is associated with stronger within-state citation (so there is a "benefit" to this policy, to be weighed against the income loss we discussed earlier)
   - About half of the difference between public and private is accounted for by differences in local development objectives

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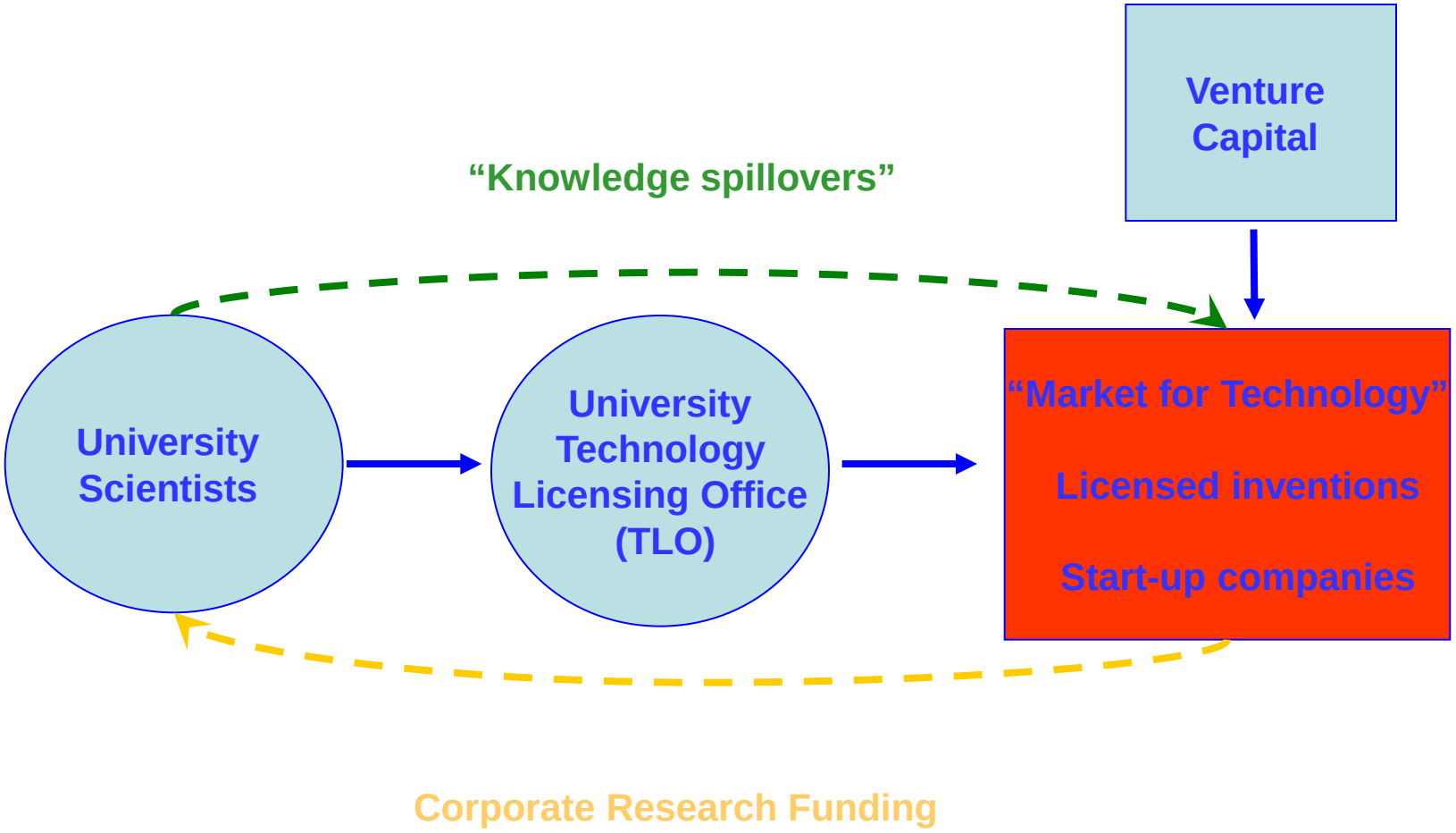

Issue 3. Organising the Best Market Structure

Current institutional arrangements

In all U.S. research universities, and most in Canada, TLO has a monopoly on commercialisation of inventions, subject to expression of no interest ("right of first refusal").

Remember: most TLO's are very small (average size < 5 professionals).

Does this market structure make sense? Are there others that might be more efficient without being more intrusive on university research activity?

There is no econometric research on this crucial issue. Even systematic descriptive work across countries would be helpful.

Alternative institutional arrangements

1. How much specialisation and consolidation should there be?

   What types of ***economies of scale/scope*** are there?

   - Administrative economies (spreading fixed overheads)
   - Informational economies: identifying potential licensees
     - By technology field across geographic locations?
     - By geographic region across technology fields?

2. Monopoly or competition in technology licensing activity?
   - Should the university TLO be the gatekeeper?
   - Why do we think “island monopolies” makes sense here, but not in other contexts?

What form might competition take?

1. **Limited Monopoly:** Impose time limits on the exclusive (monopoly commercialisation) rights of the TLO. Give inventors the right to use outside agents beyond that limit.

2. **Right to Choose**: Remove monopoly control of university TLO. Give inventors the right to use market-based agents or other TLO's or do it themselves. Possibly impose different royalty sharing depending on who intermediates. Some Canadian universities do something similar.

3. **Information Provision Only**: Make the university TLO the central information repository for university inventions. Open up the licensing activity to private firms and intermediaries.

What Else is Needed in the Innovation Ecosystem?

1. Vibrant venture capital markets
   - Facilitate new start-ups built on university research and innovations
   - 'Democratise' the commercialisation function among many firms
     - Role for start-ups and licenses to established firms varies by sector
     - Opening this up is especially important in Japan, where large firms currently dominate the commercialisation process

       [as emphasised in the book by Robert Kneller, *Bridging Islands*)

2. "Flexibility to Fail" (and Restart): Institutions that underpin risk-taking are crucial for high-tech entrepreneurship
   - Bankruptcy rules
   - Flexible labour markets (low costs of hiring and firing workers)
   - Cultural 'acceptance' of risk-taking and failure

Summary: Key Findings and Policy Messages

1. High-powered incentives for scientists and clarity of property rights are important to stimulate innovation and licensing in universities.

2. Policies are complementary: inventor incentives and TLO effectiveness reinforce each another. Need coordinated policies.

3. High-powered incentives for the TLO are effective, and not widely enough used.

4. Local development objectives are costly but generate more local knowledge spillovers. Policy debate about their desirability is needed.

5. Institutional (market) structure of technology licensing activity is important and badly structured. There is a serious need to redesign policy and introduce competition into the system.