Theories and Tools for Measuring the Impact of Research

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Research Impact & the State

- Research impact requires a long-run view
  - Short-run impact much smaller than long-run
  - First changes scientific fields, then economy
- Economic impact not why we do it, but an important story to tell
  - Not competitive but complementary
    - Positive side effect: Few jobs first, then many jobs
    - Small firms first, some grow, then new industry

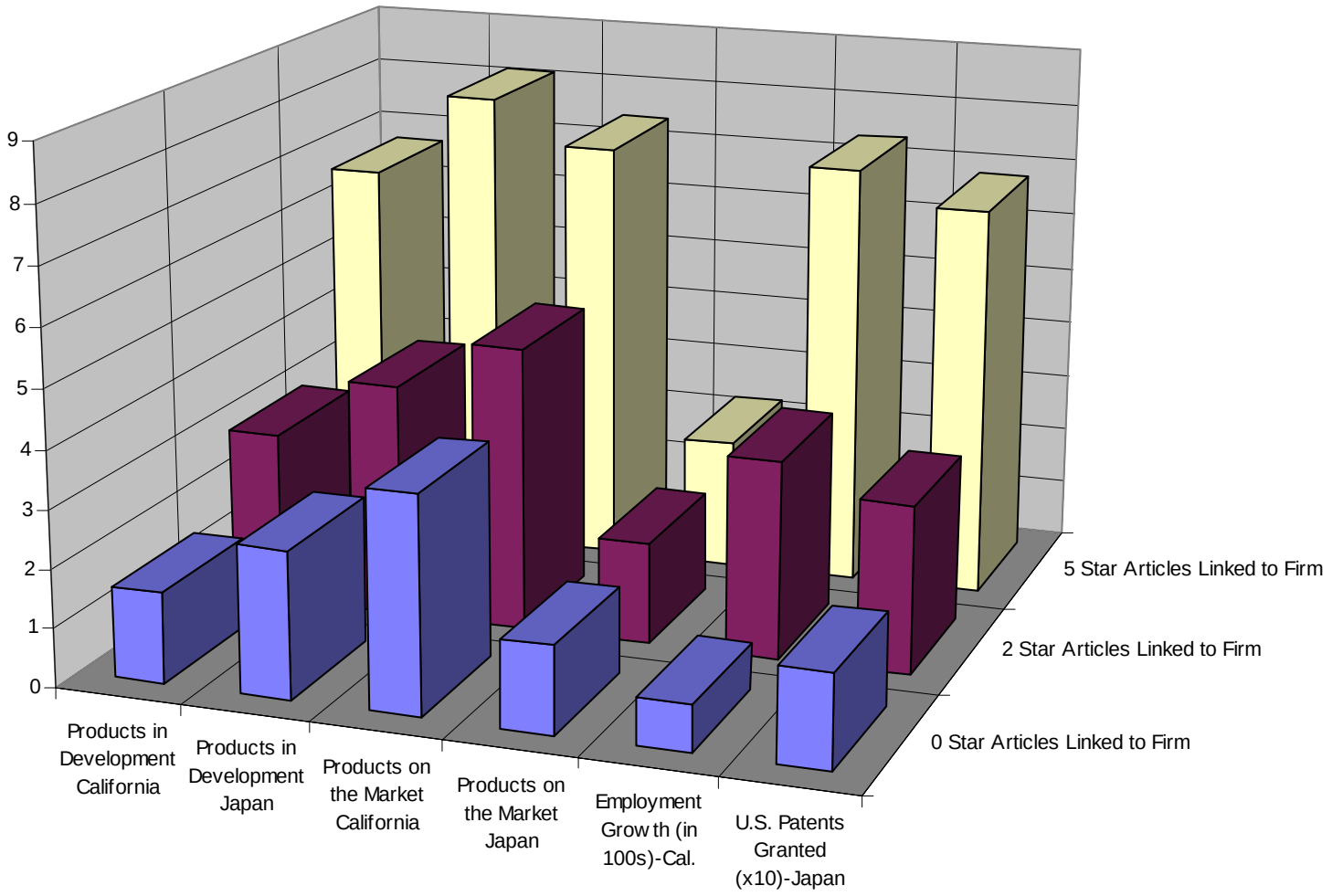
Movement of Ideas in People

- New breakthroughs are embodied in those making them
  - High amounts of tacit knowledge
  - Natural excludability protects this knowledge
    - Few know how to do it, transmit to those on lab team(s)
    - Teams located primarily in universities, but increasingly in firms
- A good mechanism gets adopted by others!

Biotech Is an Exemplar of a Science-Driven Industry

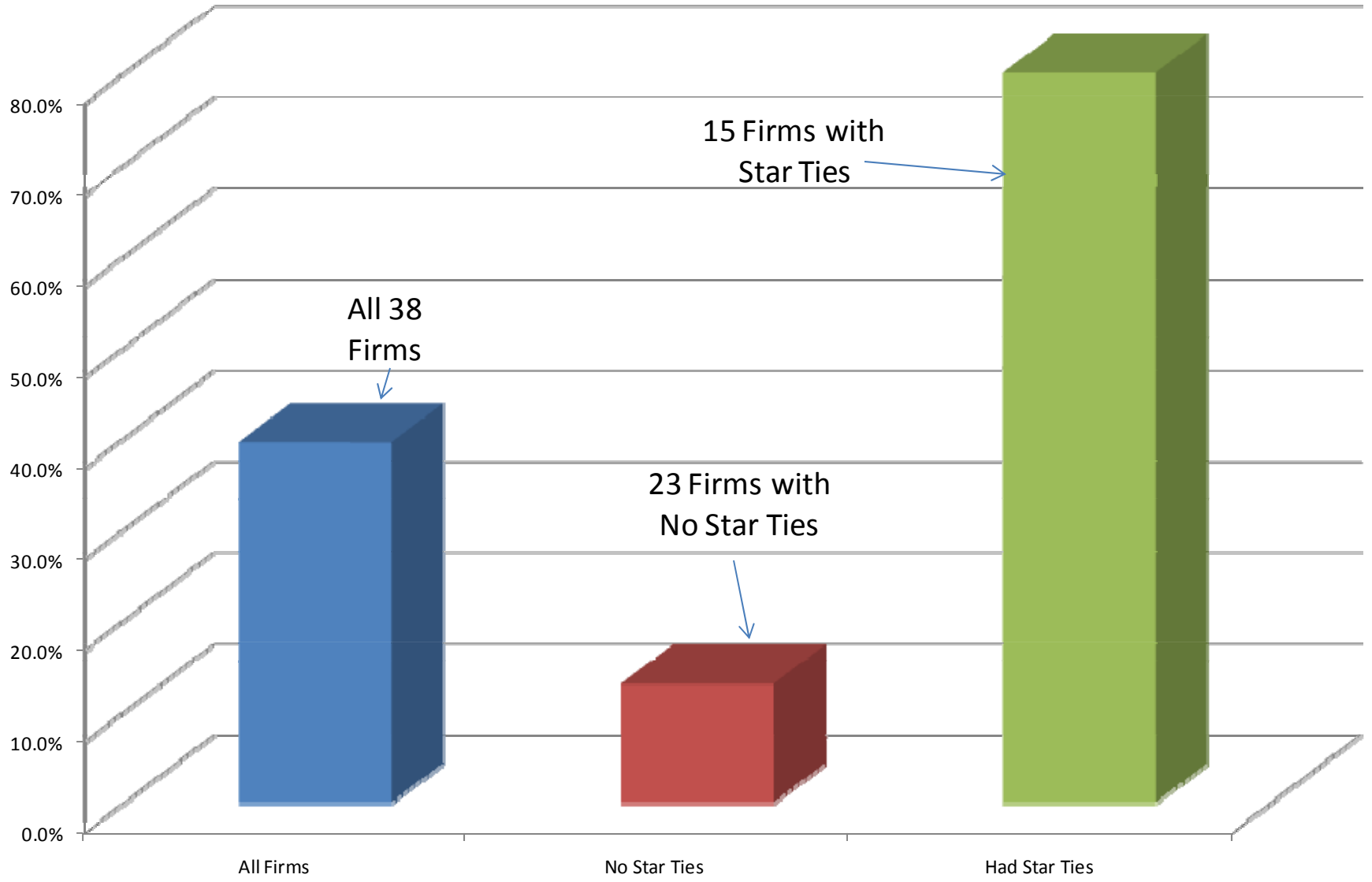
- Scientific breakthrough- 100s of firms enter
  - Many led by very best scientists & engineers
  - Consolidation when scientific advance slows
- These scientists contribute to *both* science & economic development
  - more resources ✡ research quantity, quality up
  - new job opportunities when needed badly

Estimated Effects of Number of University Star-Firm Linked Articles on Success of Californian and Japanese Biotechnology-Using Firms



Many are called, but few are chosen . . .

- Most NBFs never grew very large
  - Jobs doubled 1989-94 but only half growing
  - Winnowing process has begun in earnest
- Winners win big and even absorbed firms can win
- 2/3 of 1975 publicly-traded Pharmaceutical Manufacturers Association members gone
- The rest became biotech firms


1975 Publicly-Traded PMA (now PhRMA) Members
Survival Rate to 1999
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
All 38
Firms
23 Firms with
No Star Ties
15 Firms with
Star Ties
All Firms
No Star Ties
Had Star Ties

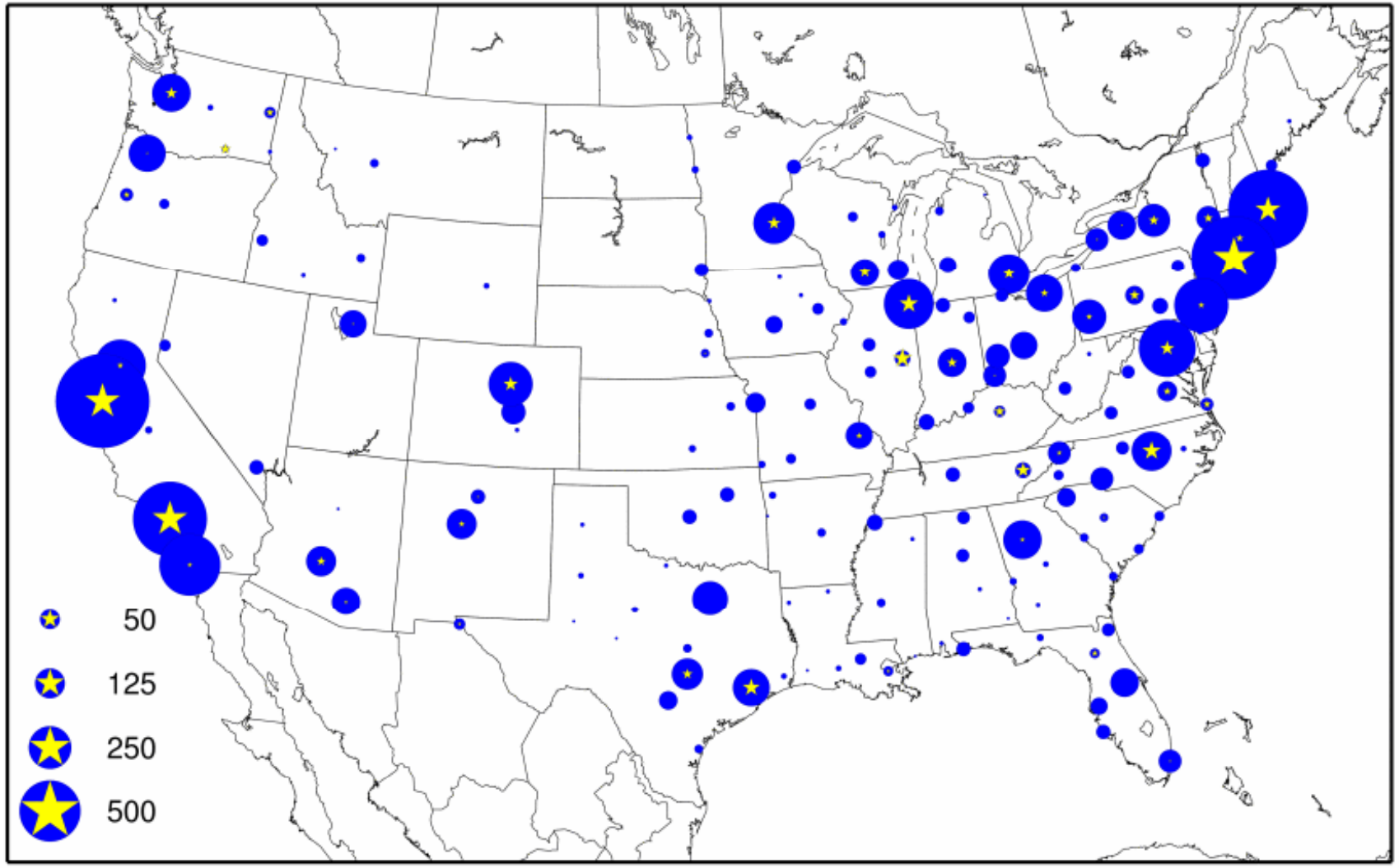
The High-Science Firm Model

- New model of high-science firm created
  - Scientists free to publish & rewarded for it
  - Deep collaborations with university faculty
  - Rewards closely tied to firm products/output
- Large incumbents learned to emulate culture and reward or died
- Many nanotech firms using biotech model

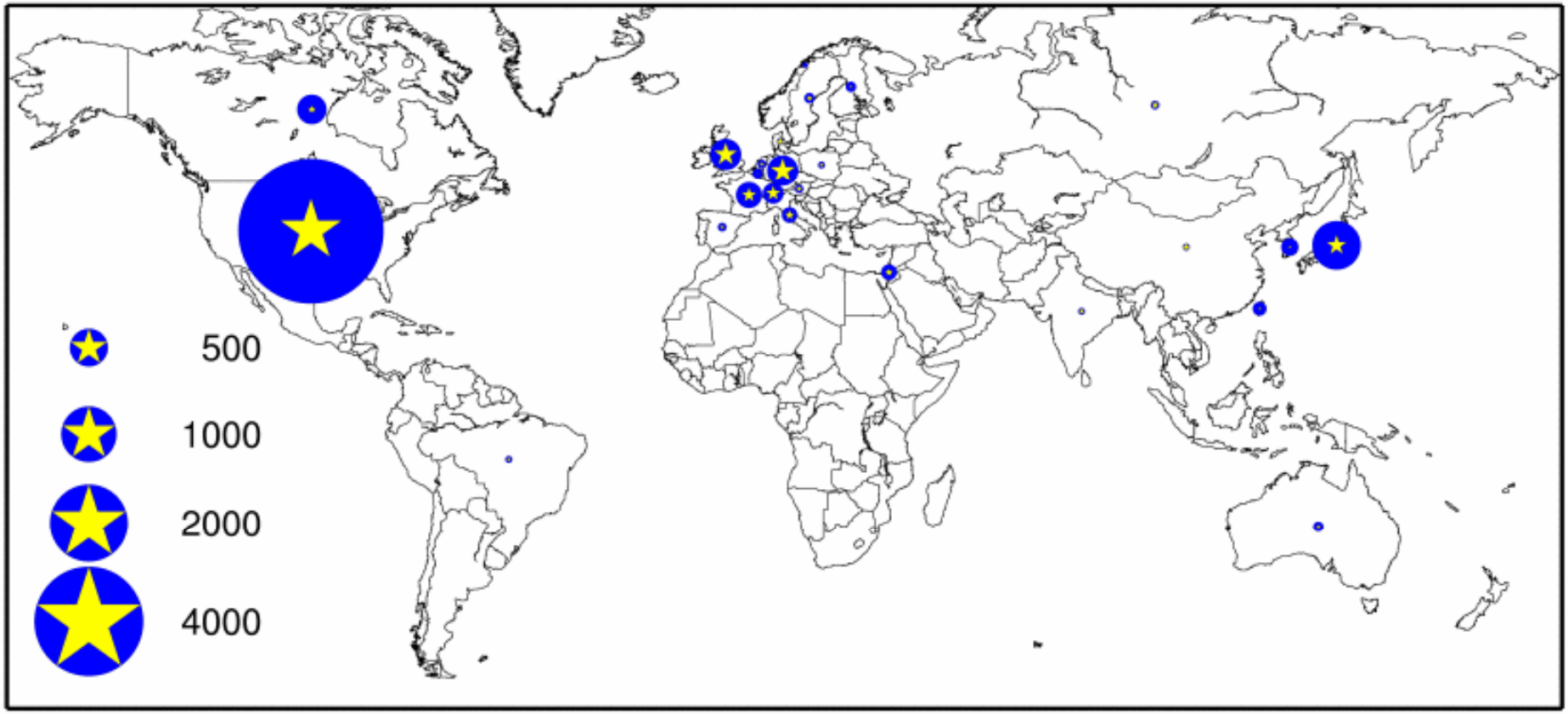
Nanotech Firms Follow Biotech's High-Science Firm Template

- Many start-ups and incumbents competing
  - Roughly 1 out of 10 have star university scientists deeply involved – bench science
  - Higher percentage of incumbents because early payoffs in semiconductors → large scale
- Where star nano-scientists active key determinant of where & when firms enter
- Star involvement → firm success

Nanoscale Science and Technology Star Scientists & Firm Entry, U.S. Regions, 1981-2004



Nanoscale Science and Technology Star Scientists & Firm Entry, 25 Countries, 1981-2004



NSF Nano Funding → Impact

- NSF targeted funding for nano
  - Large increase in published nanoscale articles
  - Large increase in nanoscale patents
- Strong effects regardless of controls
  - Analysis used nanobank.org created with NSF NIRT support
  - L.G. Zucker, M.R. Darby, J. Furner, R.C. Liu, and H. Ma, "Minerva Unbound: Knowledge Stocks, Knowledge Flows and New Knowledge Production," *Research Policy*, July 2007, 36(6): 850-863. http://dx.doi.org/10.1016/j.respol.2007.02.007

Are Federal Investments Important for All S & T Areas?

- Does role of federal investment yield knowledge flows & impact in general?
- Developing integrated database with all articles, patents, NSF + NIH + SBIR + STTR grants, and multiple-sourced firm data
- Early results beginning to flow in
  - General answer: yes, with some variation
    - True for most science areas

Stars' Debuts and Movements

	Professional debuts[b]	Outward Migration		Inward Migration		Net stock[e]	Unique persons[f]
		One-way[c]	Round-trip[d]	One-way[c]	Round-trip[d]		
OECD Member Countries[a]	**5023**	**418**	**421**	**360**	**1055**	**4965**	**6378**
Europe[a]	1194	205	107	166	635	1155	1960
Non-U.S. APEC[a] Countries	475	71	38	75	204	479	748
Australia	97	15	10	25	49	107	170
Canada	201	51	13	28	72	178	300
Japan	176	5	15	18	76	189	266
South Korea	1	0	0	4	7	5	12
United States	3354	142	276	119	216	3331	3670
OECD Nonmember Countries[a]	**82**	**23**	**6**	**30**	**116**	**89**	**221**
Brazil	1	1	0	3	15	3	19
China	4	1	0	11	26	14	39
India	10	3	1	3	14	10	27
Israel	57	13	5	4	28	48	86
Russia/USSR	7	4	0	4	27	7	36
Taiwan	3	1	0	5	6	7	14
Top-25 S&T Countries[a]	**5105**	**441**	**427**	**390**	**1171**	**5054**	**6599**

Notes: a. Totals of individual country values have not been adjusted for doublecounting due to within-region migration.

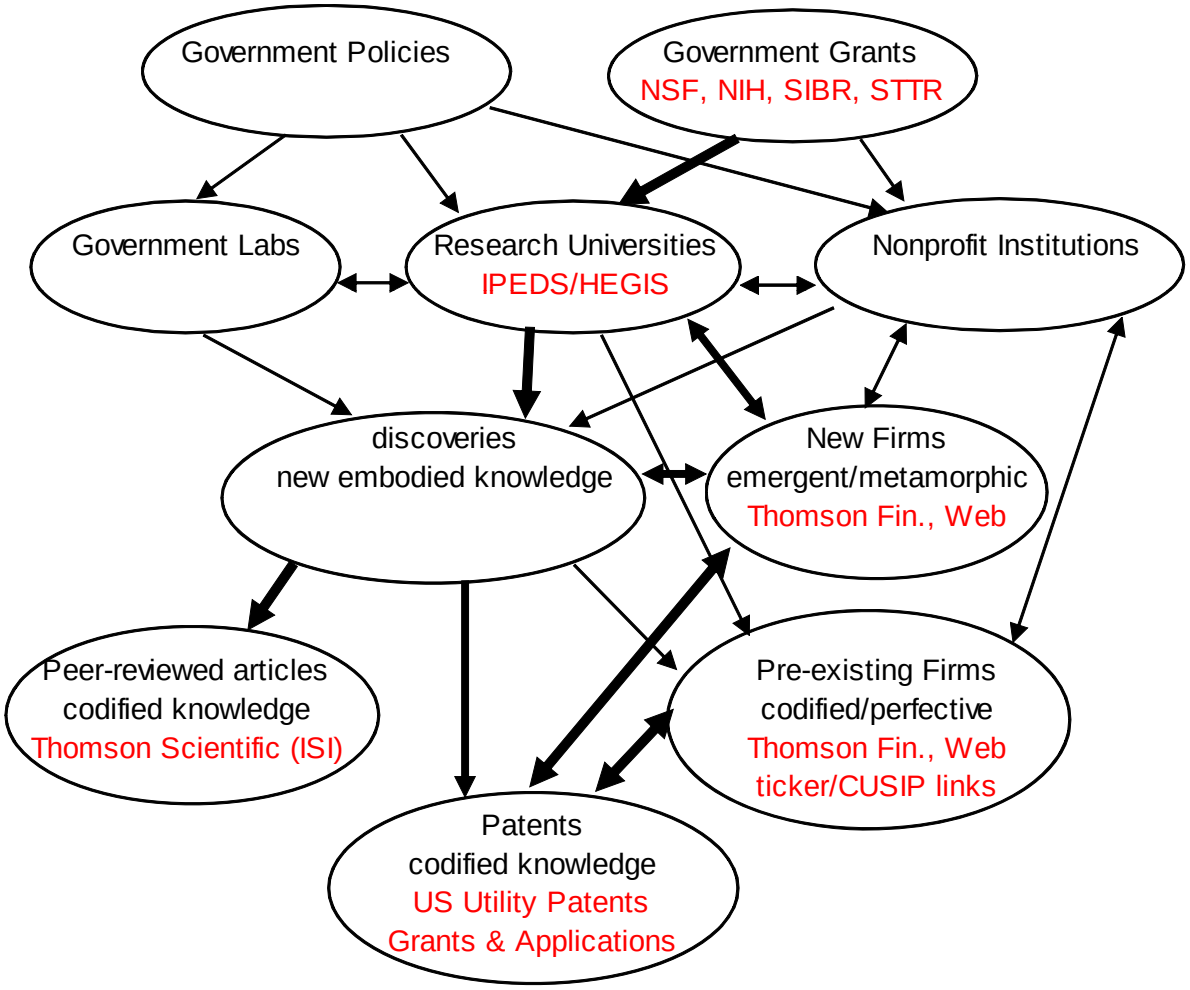
Major Early Results: All S&T

- Firms enter near where and when stars are publishing across all S&T areas
- University faculty collaborations with firms predict firm success in patenting
  - More so to the extent that the faculty are stars
  - True for both raw & citation-weighted counts
- Star impacts vary across S&T areas in proportion to technological opportunity

StarTechZD Permits Tracing Knowledge Funding, Creation & Economic Impacts

- Can ID both organizations and particular scientists within & across databases
  - Knowledge creation & flow embodied in scientists as they pursue multiple roles
  - Can separate organization & individual effects
- Quantum jump in ability to analyze S&T
  - Compare: Double-cross hybrids for seed corn, Cohen-Boyer for biotech, and scanning probe microscopy for nanotech

STAR Database Structure
Policy, Innovation, Institutional Processes, & Economic Growth



Data Sources

- Patents
  - 1976-2010-USPTO
- Grants
  - NIH grants from 1972 through 2011
  - NSF grants from 1961 through 2011
- Articles (UCLA & NBER only)
  - 1981-2005-S&T areas-Science Citation Index (ISI®, Thomson-Reuters)

StarTechZD Beta Test 1.0 Data Contents

- U.S. Patents
  - Titles and abstracts
  - Application and grant dates
  - Names and addresses of patent inventors and assignees
  - US and International patent classifications
  - Numbers and grant years of citing and cited patents
  - Zucker-Darby Science and Technology Area classifications

StarTechZD Beta Test 1.0 Data Contents

- Grants – NSF, NIH
  - Titles and abstracts
  - Receiving organization names and addresses
  - PI and co-PI names
  - Grant amounts
  - Zucker-Darby Science and Technology Area classifications
  - Nanotechnology-related flags through 2006, except Boolean flags through 2010

STAR Database Beta-Test in Process - Invitation to Participate

- Details at StarTechZD.net
- ~90 users out of 100 capacity for β-test
- First installment of data on US patents, NSF and NIH Grants through 2010
  - Fully integrated: ID geography & organization
- Much more underway - but some limited to users at UCLA & NBER