The Localization of Innovative Activity

Characteristics, Determinants and Perspectives

Giovanni Peri (University of California, Davis and NBER)

Prepared for the Conference
Education & Productivity
Seattle, July 2005

Preface

- This is a talk about
  - Innovation (=Discovery of new goods and processes that enhance our ability to satisfy our wants and increase our well-being)
  - Localization (=why does innovation takes place in some – very few- places in the world ***and few specific regions within the US***)?

Why Innovation?

Knowledge is our most powerful engine of production; it enables us to subdue our nature and satisfy our wants"

(Alfred Marshall)

- Innovation is the Main Source of Productivity Growth for Developed Economies and of their "Comparative Advantages"

- Innovation is the Source of important short-medium run accelerations/slow-down–e.g. Success of the 90's, *as seen in Stiroh's talk.*

Why Localization?

- One of the most striking feature of the Innovative Activity is its **geographical concentration** even relative to other economic activities (production) which are themselves very spatially concentrated.

- This is true at all levels of geographical aggregation (Country, State, City).

Examples

USA

Variable	3 Largest State Economies (Ca, TX, NY) as % of total US
Land Area	12%
Population	25%
GDP	28%
Innovation (Measured as Patents)	35%

California, Washington

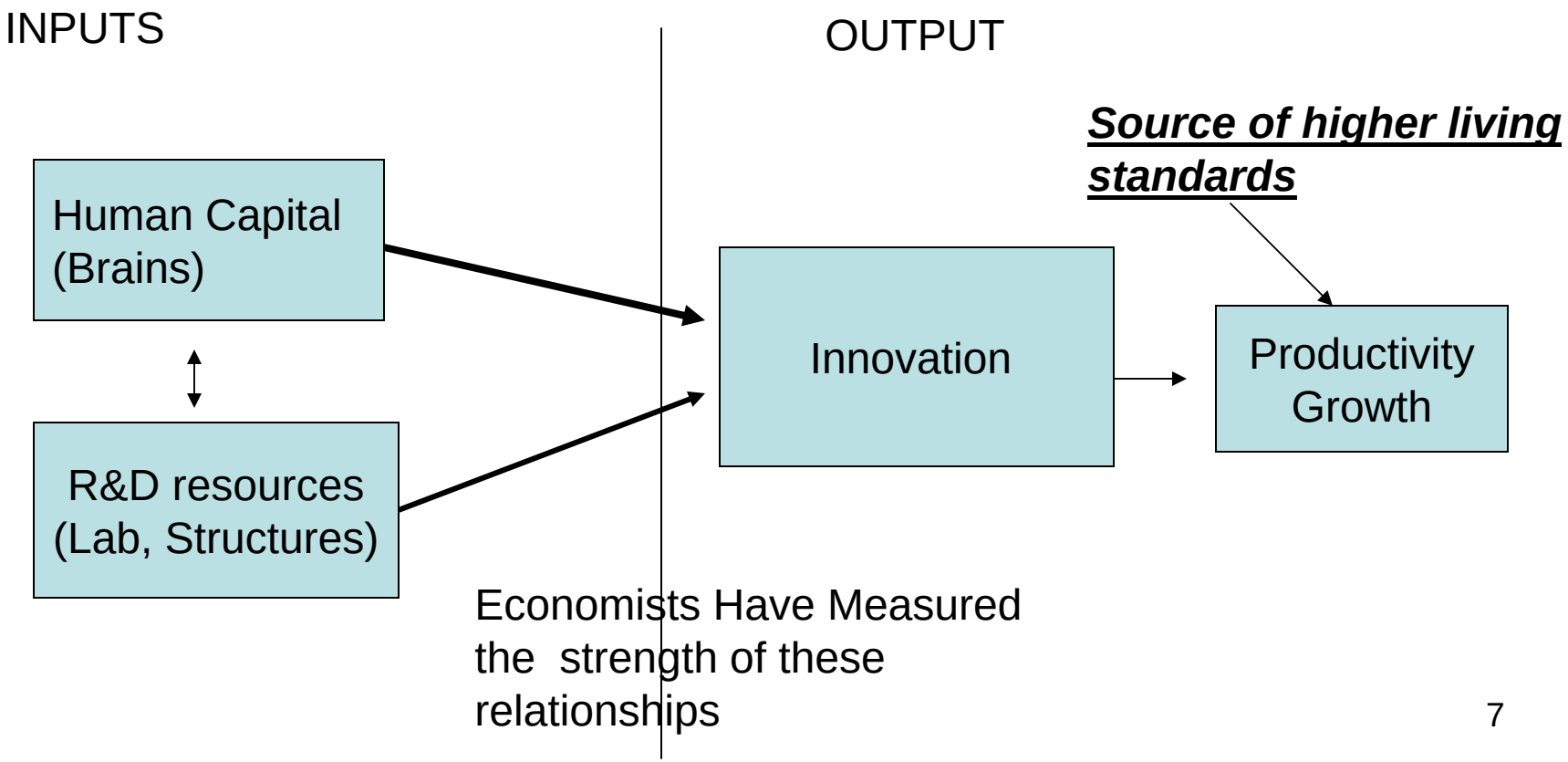
Variable	Largest Metropolitan Economy (Seattle Metropolitan area) as % of total Washington	Largest Metropolitan Economies (SF, LA and SD) as % of total California
Land Area	6%	10%
Population	40%	51%
GDP	53%	67%
Innovation (Measured as Patents)	72%	90%

Outline of the Presentation

- Basic Framework and Measures of innovative activity
- Documenting the extraordinary “concentration” of innovative activity
- Exploring the Sources of Concentration: Local knowledge spillovers
- Through which channels do Local Knowledge spillovers operate?: The Importance of geographic proximity of Human Capital, Universities and Innovation

Basic Framework to represent and measure the Innovative Activity

- Generating Innovation



1) Inputs of Innovation

- How to measure Human Capital?
  - College Graduates
  - Ph.D.s
  - Employed in “High tech” sector
  - Scientists and Engineers

  Units are normally “number of people” or Hours Worked

  Example: Increasing Scientists and Engineers in a state by 1% increases its innovation by 0.6-0.8%

- How to Measure R&D resources?
  - R&D spending by private sector and government

  Units are real $

  Example: Increasing R&D spending per scientist in a state by 1% increases its innovation by 0.2-0.3%

2) Measures of innovation (output)?

- Most reliable, rich and comprehensive data about innovation are Patent data.

  – Caveats:
    - One Patent is a new Idea, however their importance vary widely.
    - Some Innovations are not Patented

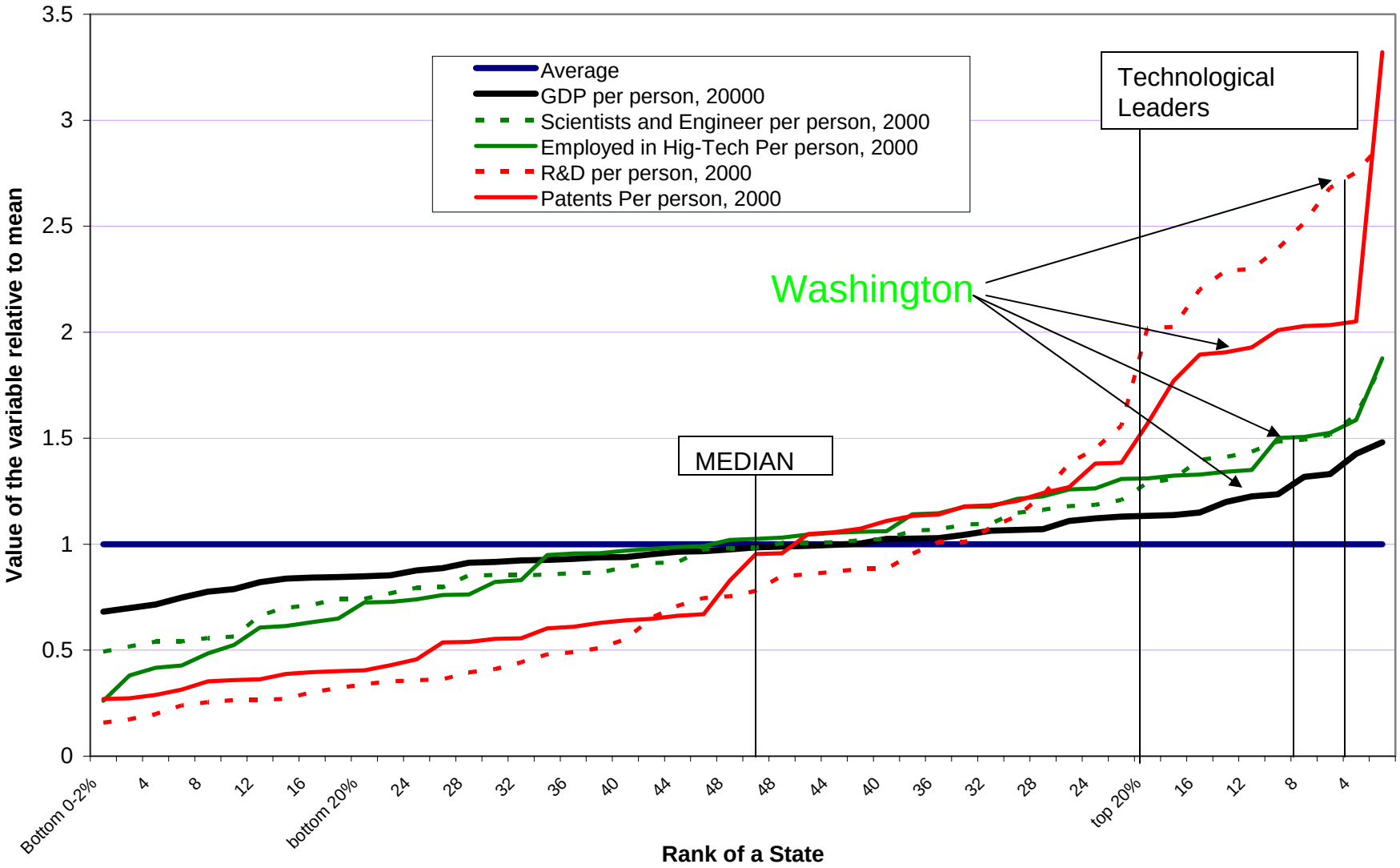
3) What are the relevant “units” in the innovative process?

- Economics of innovation recognizes that crucial interactions happen outside firms as Innovative firms tend to “cluster” in some locations to participate in local benefits.

- Countries, States, Cities matter. Innovators form networks and interact among themselves and geographical proximity seems to be very important.

- Economists document that firm which are responsible for most innovative activity tend to be highly geographically concentrated. This is very interesting per se and has interesting implications.

US States: production and Innovation

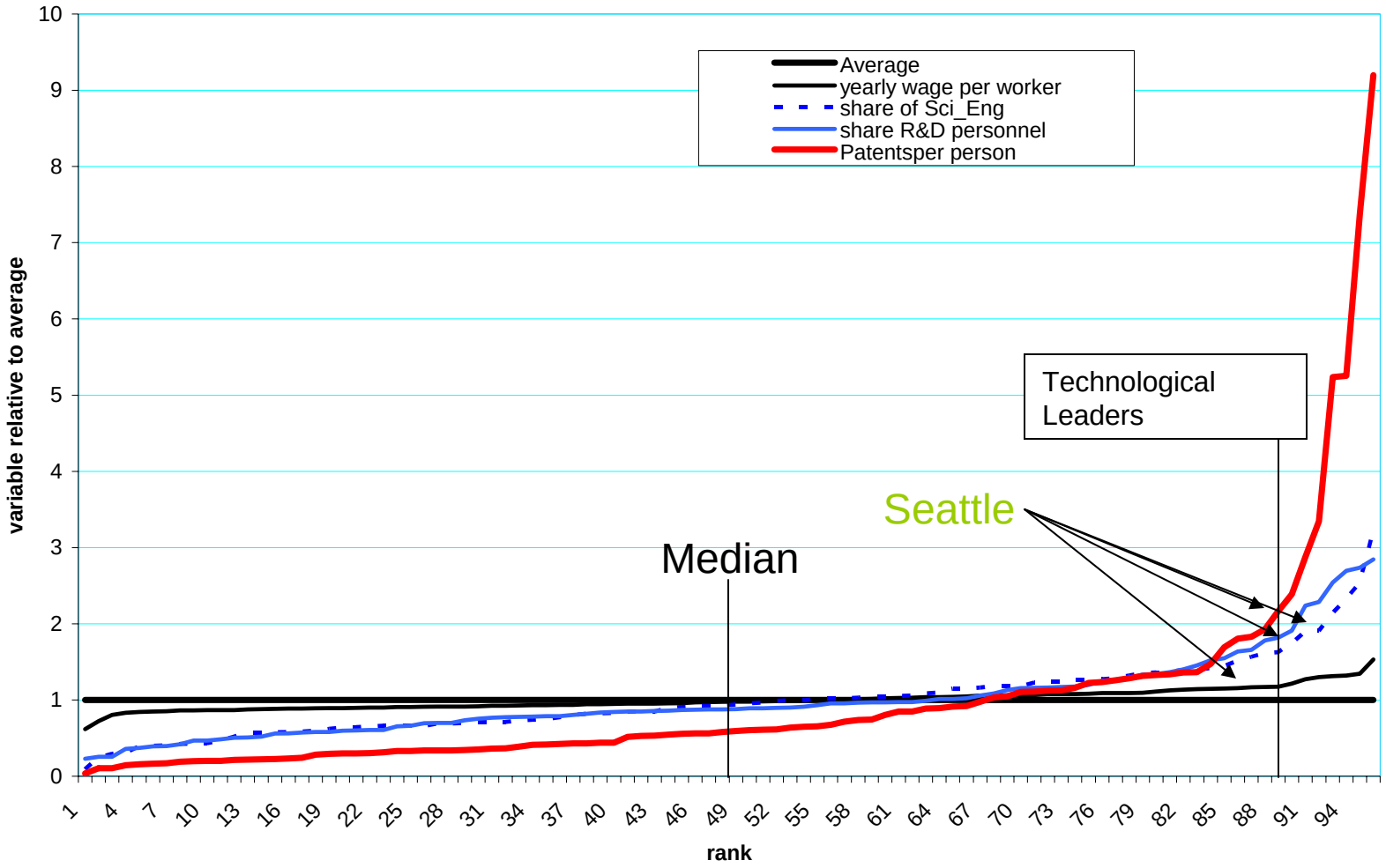


Washington State, 2000

measure	Rank of Washington	Top State
GDP per person	10th	Delaware
College Graduates as % of population	14th	Maryland
S&E College Degrees conferred per 1000, 18-24 years old	35th	Vermont
Scientists and Engineer as % of Population	8th	Massachusetts
Employment in High Tech as % of population	7th	Massachusetts
R&D per person	4th	Massachusetts
Patents per person	13th	Massachusetts

Source: Census 2000, NBER Patent Data file 2002, NSF S&E indicators 2004

100 US Metropolitan Areas: Production and Innovation



Seattle Metropolitan area 2000

(includes Everett, Bellevue, Redmond, Kirkland, Issaquah, Bothell…)

measure	Rank of Seattle	Top Metropolitan Area
Average wage per person	13th	San Jose, Ca
Scientists and Engineer as % of Population	6th	San Jose, Ca
Employment in R&D as % of population	9th	Raleigh-Durham NC
Patents per person	10th	Rochester, NY

Source: Census 2000, NBER Patent Data file 2002.

What does concentration imply?

- Firms and entrepreneurs that do innovation should consider the previous graph as a menu of opportunities. They are not choosing location on a "flat earth". If location implies "absorbing" from the local environment there are large incentives to be in the "leading locations" .

- Cities, states should look at the previous graph and consider it as a measure of "potentials". Where are they, relative to "the cliff of technological leadership"? What put some cities and states to the right of that cliff?

What does Concentration reveal?

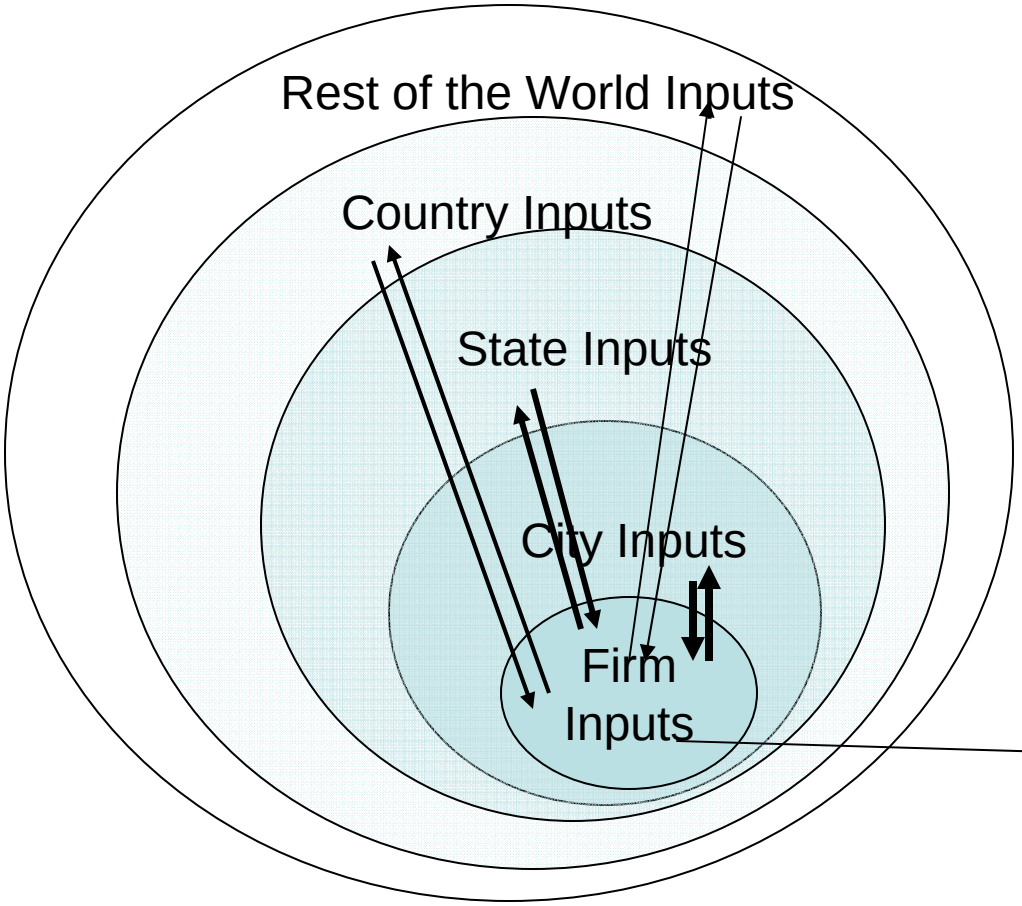
- The forces driving self-reinforcing innovative activity are stronger than those driving self-reinforcing productive activity.

- In production offsetting forces (crowding, increase in prices of local land, building, resources) INHIBIT concentration. The opposite holds for Knowledge

- What are these local self-reinforcing mechanisms? They seem linked to local diffusion of important knowledge called “local knowledge spillovers”.

- They are very strong “at the top” i.e. among the very leaders. Why? Threshold, few “stars” make difference

Revisiting the Frame



The Arrows represent "local Knowledge Spillovers" namely benefits, decreasing with distance, of interacting with innovators and having access to the ideas they generate.

Innovation

“Knowledge Spillovers”

- Knowledge is a factor of production like no other produced in an economy. It “spills over”. It cannot be (fully) contained once it is generated and it affects other innovators. It can be used by other to produce other ideas. This is the source of the “virtuous circle” called “increasing returns”.

- Knowledge spillovers and increasing returns have been identified by growth theorists to be at the heart of sustained economic growth

- **However why doesn’t it spill to the whole world?**

- Geographical proximity seems to ensure that the mechanisms of knowledge diffusion are enhanced. The presence of a large number of local innovators increases externalities, attract further innovators and feed the mechanism.

Quantifying the importance of Knowledge Spillovers: some examples

- Innovation of an average firm increases by 4-5 % for every 10 % increase in average state R&D, keeping its own R&D constant. The same increase of R&D in a state sharing the border would only have a 1% effect (Peri 2005)

- An increase in R&D of other private firms within the state by 10% would generate an increase in innovation by 8-9% in the average private firm. (Jaffe)

- Increasing University R&D by 10% in a state increases innovation of private firms by 2% on average.

  Important Qualifications:

  1)Small firms more than large firms benefit in particular from R&D done at local universities.

  2) Higher R&D in University by 10% induces higher private R&D by 7%. The reverse effect is much smaller (1%).

- For High-tech industries increased R&D by 10 % by in other firms within the industry decreases costs by 2% (i.e. increases productivity) (Bernstein and Nadiri)

Patent Citations Reveal Knowledge Diffusion

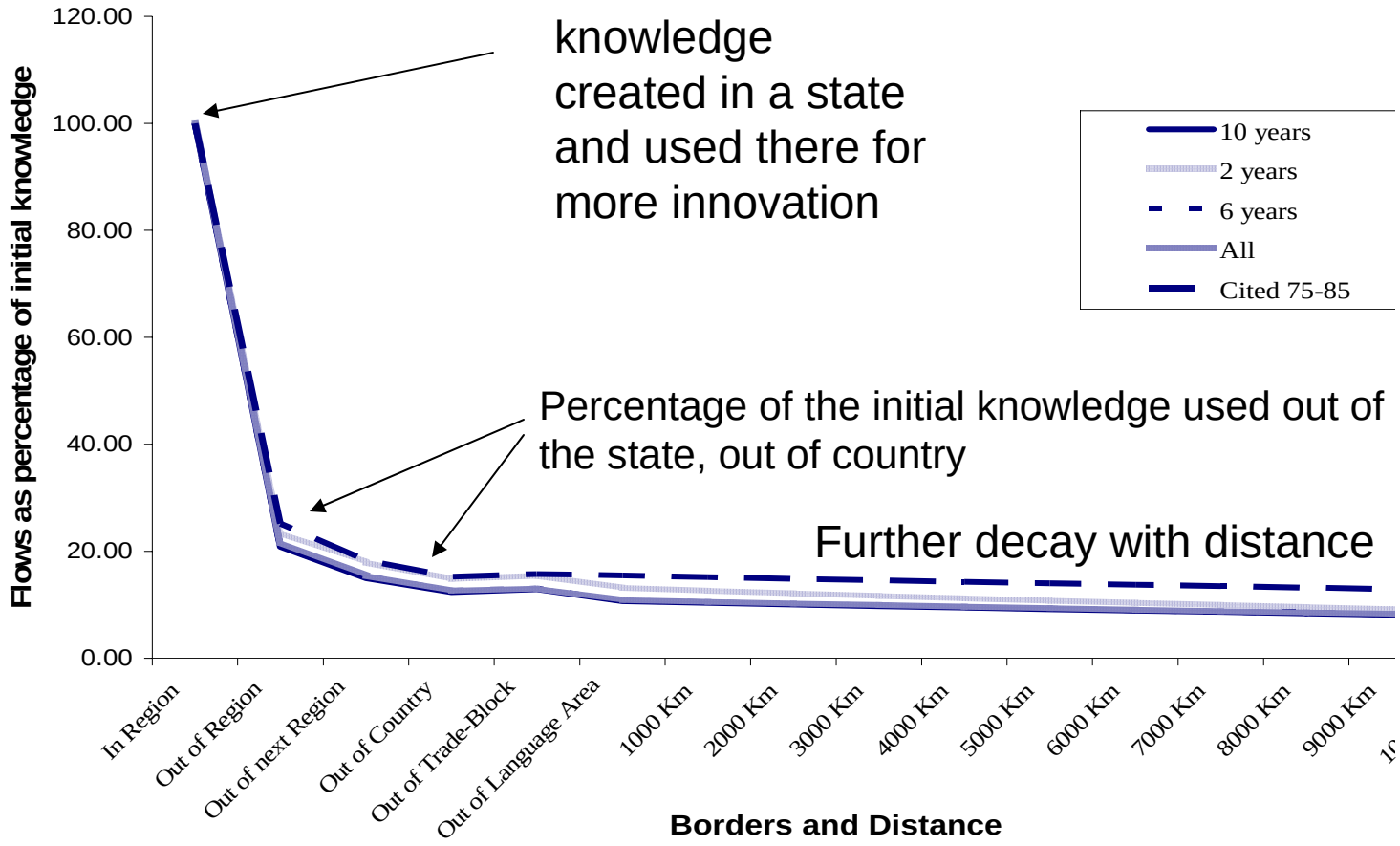
- The importance of “knowledge spillovers” has pushed economists to look for direct measures of their intensity.

- Patent data have “citations” to prior work that was used to develop the innovation. Following these citations we have a “paper trail” to:
  - where DID innovator LOOK for inspiration?
  - who do they talk to?
  - How far in geographical and technological space do idea travel?

  we can construct the geography of these knowledge externalities.

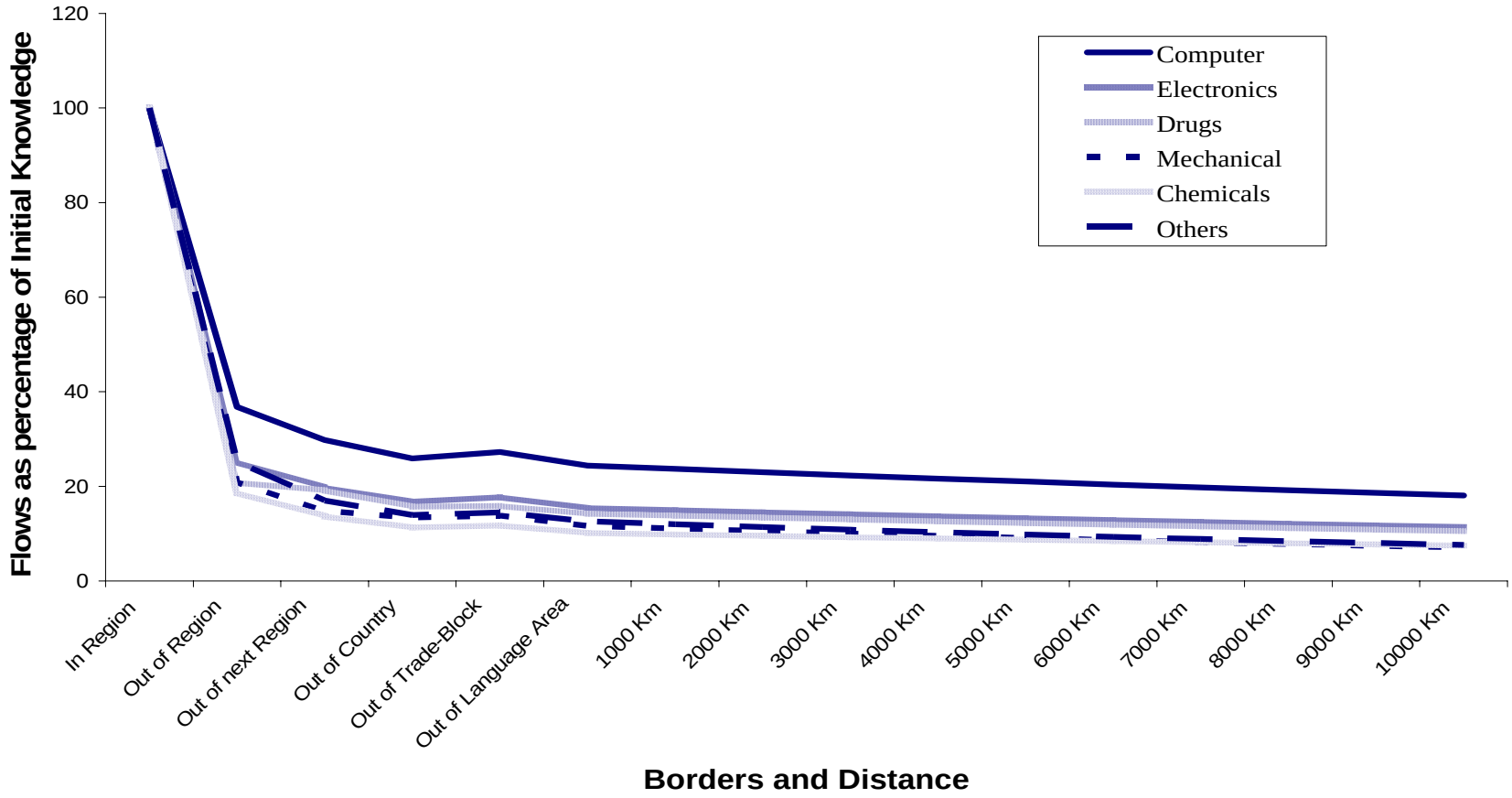
  Relative intensity of citation to a source (patent) is relative intensity of use of knowledge from that source

Pattern of technological “knowledge diffusion” as derived from patent citations



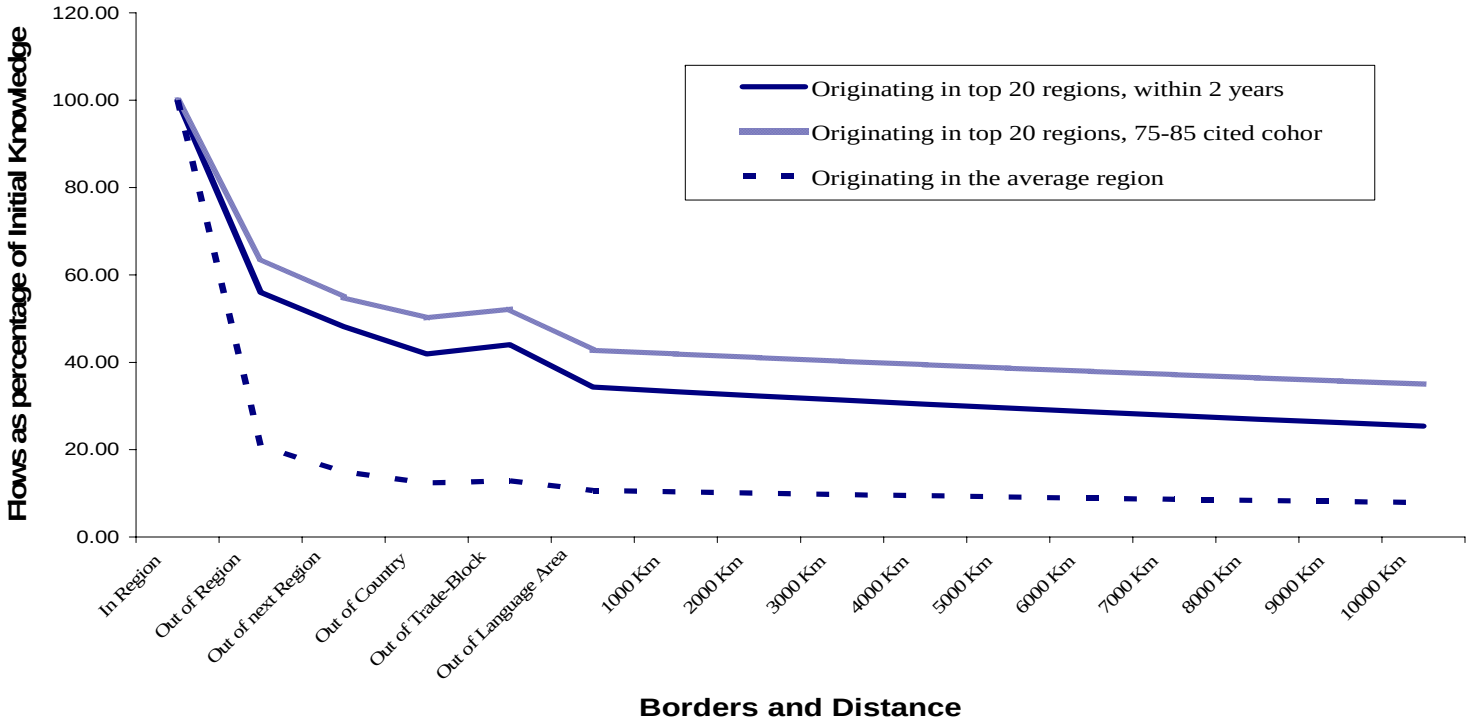
From Peri (2005). Region= 50 U.S. states, 10 Canadian Provinces and 80 EU sub-national regions. Ideas are mostly used locally by other innovators.

Pattern of technological “knowledge diffusion” for specific Sectors



Computer sector has a degree of “globalization” larger than the others

Pattern of technological “knowledge diffusion” diffusion originating from the Technological Leaders



Technological leaders generate ideas that inspire research further in space. Big Ideas travel far. Leaders are source of further innovation.

Why is knowledge so “sticky”?

- 1) People tend to talk/interact more with people in geographical proximity

- 2) People move locally bringing from a firm to another (or from a university to a firm) their knowledge. Employees of local firm-university become entrepreneurs in spin-off firms.

- 3) While information (well codified) is easy to transfer across long distances knowledge of new not codified products-ideas is hard. Early in the innovation process a lot of knowledge is tacit, “embodied” in people.
  - Innovation relies on large amounts of embodied knowledge
  - Production has a larger part of codified knowledge.

Life-cycle of new ideas

- 1) When an innovative idea emerges, as result of R&D and creative minds, it embodies a large amount of “tacit, not codified” knowledge. Very high concentration around the innovators.

- 2) When the idea is developed into a new product still very intense interactions are needed between inventors and producers, but more of the initial knowledge is codified. High concentration.

- 3) Once the product is well developed and the knowledge behind it becomes “standard”, production can move where the cost of labor is lower. Lower concentration.

Importance of location of “talent”: Example: The birth of Biotechnologies

- The very rapid development of use of biotechnology in food-processing, pharmaceuticals, brewing firms in the 1976-1989 period seems explained by one single major factor: the location of a scientist who is publishing path-breaking research in the related basic scientific field (total are 134).

- No other determinant of innovation is more important than the location of talents (Zucker and Darby)

- ***One more star scientist in a city translated into 22 more bio-tech start-ups by 1990 (total of firms documented to use biotech by 1990 was 750).***

- ***One more top quality University (top ranking in biochemistry-molecular biology) translated in 30 more firms using bio-tech.***

- Key role of Universities, in attracting these “star scientists” i.e. those publishing path-breaking research in the relevant field (genetic sequencing, semi-conductors, information technology).

Active Star Scientists and New Biotech Enterprises

Stars and Human Capital

- A few star Patent holders can move geographically their firms, and local innovation activity moves with them. (Almeida and Kogut).

- Not only superstars matter, however. Just as important is the high quality of research universities and the average level of knowledge of a city (region) in determining innovation, productivity and growth (Glaeser et al, Rauch, Moretti, Bartel and Lichtenberg)

Entrepreneurs and Start-ups

- Often crucial agents carrying local spillovers are employees of large companies or University professors that own critical knowledge and generate start-ups.

- Not only “intellectual stars” matter but also “entrepreneurial stars” (Audretsch, Feldman) are very relevant for local knowledge spillovers

- Local Networks. Focus on the role of entrepreneurs-Universities-Labs-consortia in generating clusters of firms with very strong connections and ties.

Cutting Edge Insights

Science-Based Diversity and cross-fertilization of Ideas.

- Not only within sector concentration matters (silicon valley) but also an appropriate diversity of sectors nurturing the core (Jacobs, Glaeser et al).

- Large metropolitan areas (New York, Los Angeles) have based their success on the presence of many sectors, cross-fertilizing each-other. Recombining ideas, applying them to different problems has always been a source of innovation.

- Some studies (Audretsch and Feldman) show that scientific diversity enhances innovation.
  - For instance innovation in the “high-tech” computing sector draw from research in the fields of Material Science, Computer science, Physics and Math.
  - Conversely research in Material science is also relevant In Chemical Engineering and Industrial Machinery

What have we learned?

1) Knowledge spillovers are localized, location matters for innovative firms and innovation is the key to growth.

2) Interactions between Intellectual Superstars, entrepreneurs, Universities and firms R&D are the key variables at the local level

3) Specialization and Diversity in high-tech sectors and research are both fundamental ingredients

4) What are the Benefits of being (becoming) a leader: Reinforcing the virtuous circle, having visibility and demand from the rest of the sector.

Food for thought: Applying it to Washington State

- Washington state and Seattle are the stage in which the reinforcing effect of knowledge spillovers can have very strong impact (right at the “cliff” of innovation leadership) potentials are huge,

- Important for Washington state to understand what sectors forms its innovative core, how to capitalize on its spillovers facilitating further concentration and promoting science-based diversity.

- How are local universities attracting scientific stars? Which one are? How are they connecting with small and large private R&D? How do R&D in private sector and in University complement each other? (E.g. “Bio21” report by Tech-Alliance on research-Government and community interacting on an interesting life-science project)

Applying it to Washington State

- Human Talent is key. Continue to attract talented young people (quality of life, urban development policies, local transportation)
- Increasing number and quality of local college graduates, locally grown scientists and engineers
- Geographic proximity to massive R&D (Microsoft and Boeing) is a unique opportunity for universities and small firms. What are the connections?
- Does Washington state have a plan that outlines its competitive core clusters and their diverse sector needs and their resource requirements? (see, interesting project, prosperity Partnership, Puget Sound Region economic Strategy)
- Lessons from California: How to manage the “curses” of success: congestion, local services, price of housing?