Geography & Innovation: Exploring the Drivers of National Innovative Capacity

SMG Breakfast Briefing

March 15, 2006

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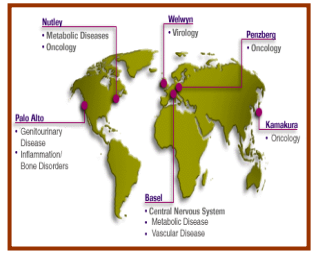
* These slides build on research conducted with & presentations prepared by Michael Porter (HBS) & Scott Stern (Kellogg). The presentation also draws data from multiple projects and papers, so tables & figures may vary in their underlying datasets. All errors are my own.



Questions to start the morning

1. *Why are some countries more innovative than other countries?*

2. *Why are some regions of the USA more innovative than other regions?*

3. *As telecommunications advance, location no longer seems to matter – individuals and firms can locate & thrive anywhere.*
   - *do you agree or disagree?*

Two key motivating facts

- Historically, the club of the world's most innovative countries has been relatively small
  - and leadership in the club has been stable over time

1. **The club has expanded**
   - as some previously industrializing countries have devoted increasing share of resources to innovation
   - e.g., S-Korea, Ireland, Israel, Taiwan, Singapore
2. **The gap between the most innovative and the rest in the club has narrowed**
   - less innovative members have improved their innovative capacity to a greater rate than the historically most innovative members

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Who am I? (I)

- Grew up in **Philadelphia**
- Undergraduate studies
  - **University of Pennsylvania** (B.A., Psychology)
  - **U. Penn – Wharton** (B.S., Economics)
- Work experience
  - Health Care Consulting *(DC)*
  - Fulbright Scholarship – WZB *(Berlin, Germany)*
- Graduate School
  - **MIT – Sloan School** (PhD)
  - *additional research experience at Wharton & HBS*

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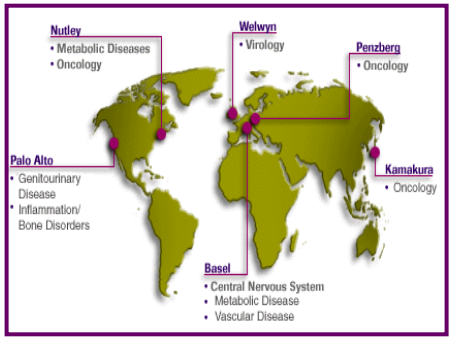
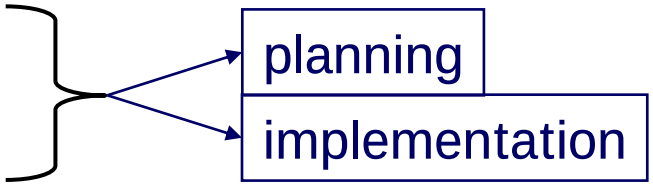
Who am I? (II)

- *Boston University (since 2001)*
  - *Assistant Professor – Strategy & Policy*
  - *Teaching:*
    - *Strategic Management*
    - *Technology Strategy*
- Research on innovation & strategy
  - *Why are some countries more innovative than others?*
  - *Why are some pharmaceutical firms are better at coming up with new drugs than others?*
    - *How do firms choices about where to put their laboratories affect their productivity?*
  - *How do institutions affect scientific progress?*
  - *What is the effect of the Bush Stem Cell Policy on regional scientific advantage?*
  - *http://people.bu.edu/furman*



Issues for the Morning (I): Location, Innovation, & Strategy

- **Location Paradox:**
  - despite improvements in innovation technology that ease communication across great distances, location has not become irrelevant to economic activity
  - if anything, location has become more important
    - cities & regional clusters experienced resurgence since 1990s
    - e.g., life sciences in MA, wine in CA, oil in TX, med tech in MN
    - *local characteristics can aid firm competitiveness & innovation*
- Location, Innovation, & Strategy lessons:
  - firm-level
  - region-level
  - country-level

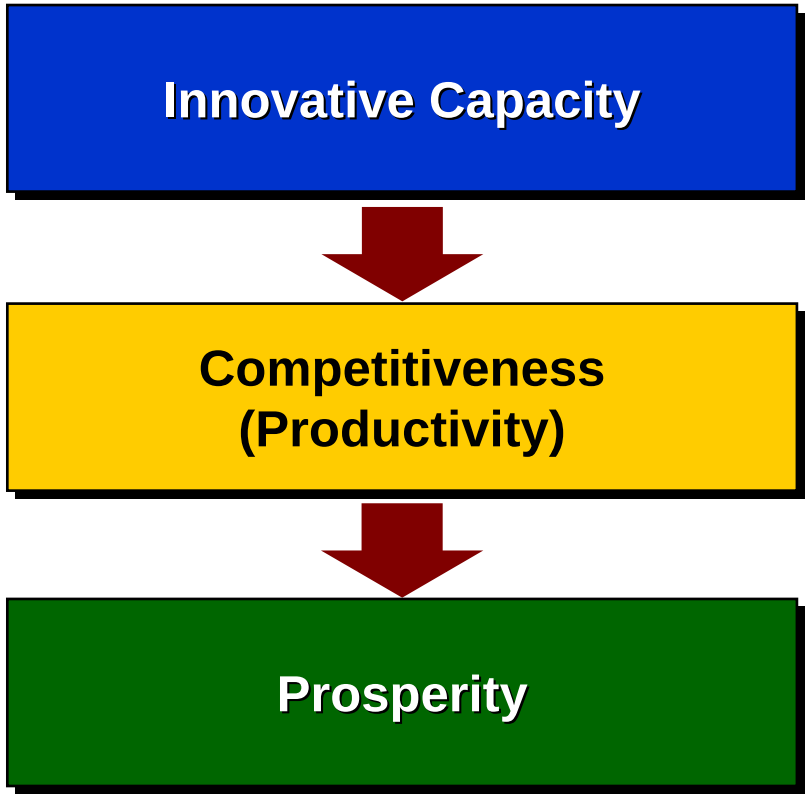


Issues for the Morning (II): Key questions about Location & Innovation

- *Why are some regions (countries) more innovative than others?*
  - *What regional (national) characteristics lead to innovative leadership (stagnation)?*
- *Why does it matter?*
  - *for society / for the economy?*
  - *for specific firms?*

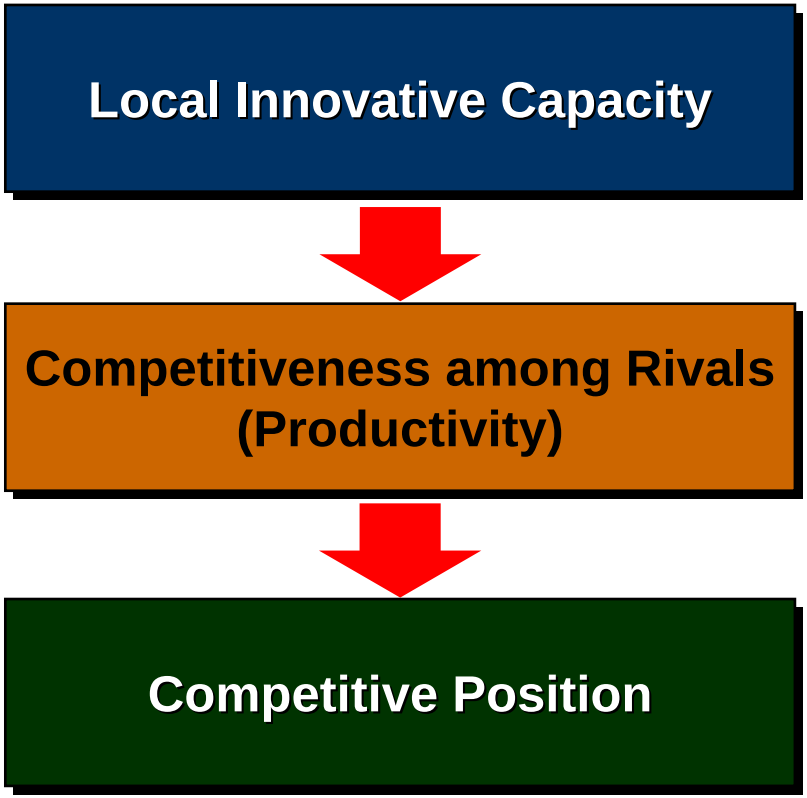
Innovation, Competitiveness, & Prosperity

For advanced economies, the ability to innovate at the global frontier is crucial for maintaining competitiveness in the face of evolving regional and national challenges



Innovation, Competitiveness, & Prosperity

For firms in advanced economies, the ability to access knowledge at the global frontier & the need to compete with world-class rivals encourages continuous upgrading of firm capabilities and competitive position



Sources of Prosperity

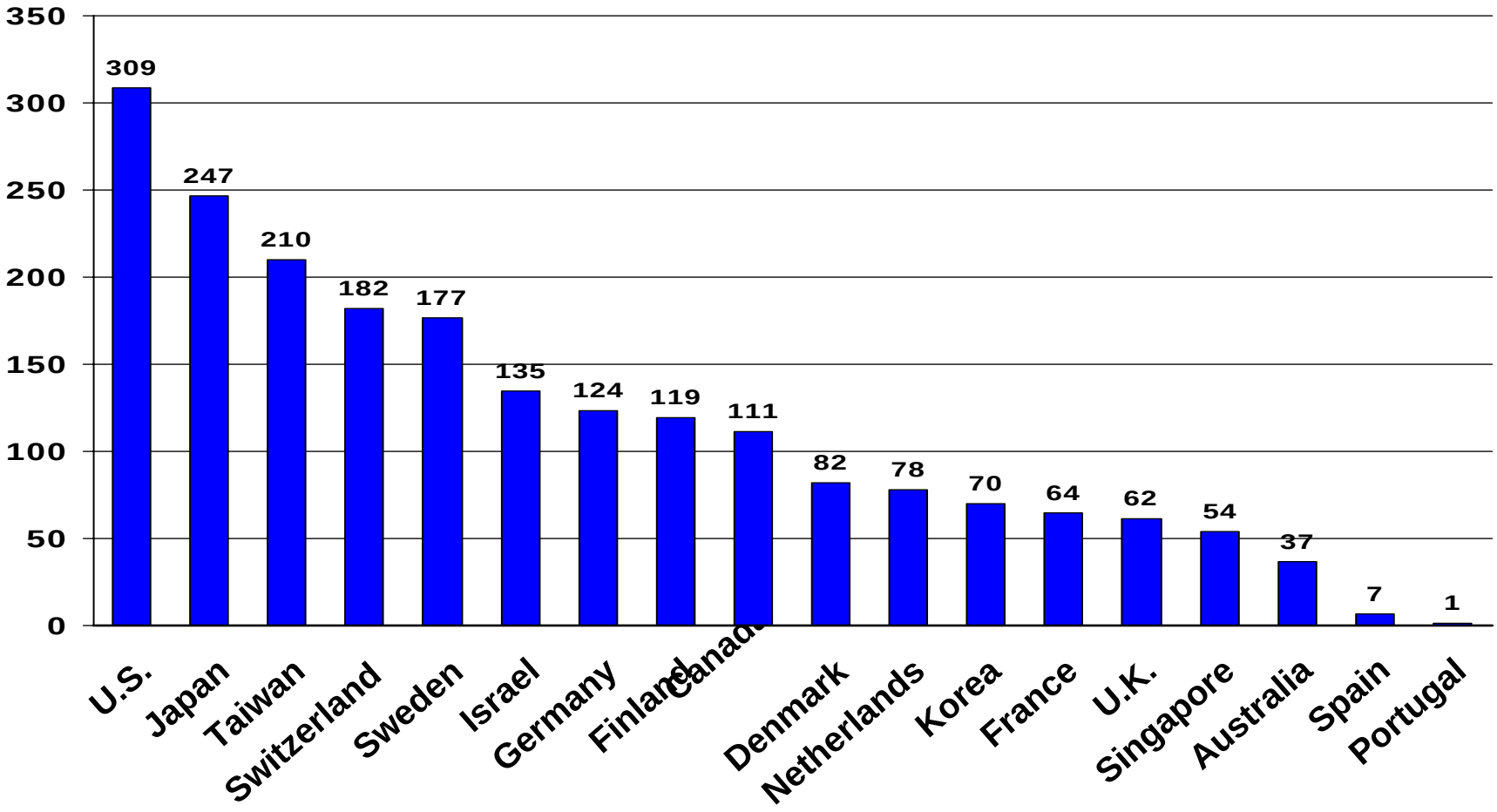
- A nation's or region's standard of living (wealth) is determined by the **productivity** with which it uses its human, capital, and natural resources. The appropriate definition of competitiveness is productivity.
  - productivity depends both on the **value** of products and services (e.g. uniqueness, quality) as well as the **efficiency** with which they are produced.
  - it is not **what** industries a nation or region competes in that matters for prosperity, but **how** firms compete in those industries
  - productivity in a nation or region is a reflection of what both domestic and foreign firms **choose to do in that location.** The location of ownership is secondary for prosperity.
  - the productivity of **"local"** industries is of fundamental importance to competitiveness, not just the productivity of industries engaged in int'l trade

- Nations or regions compete in offering the **most productive environment** for business
- The public and private sectors play **different but interrelated roles** in creating a productive economy

Background:
Key facts about Location & Innovation

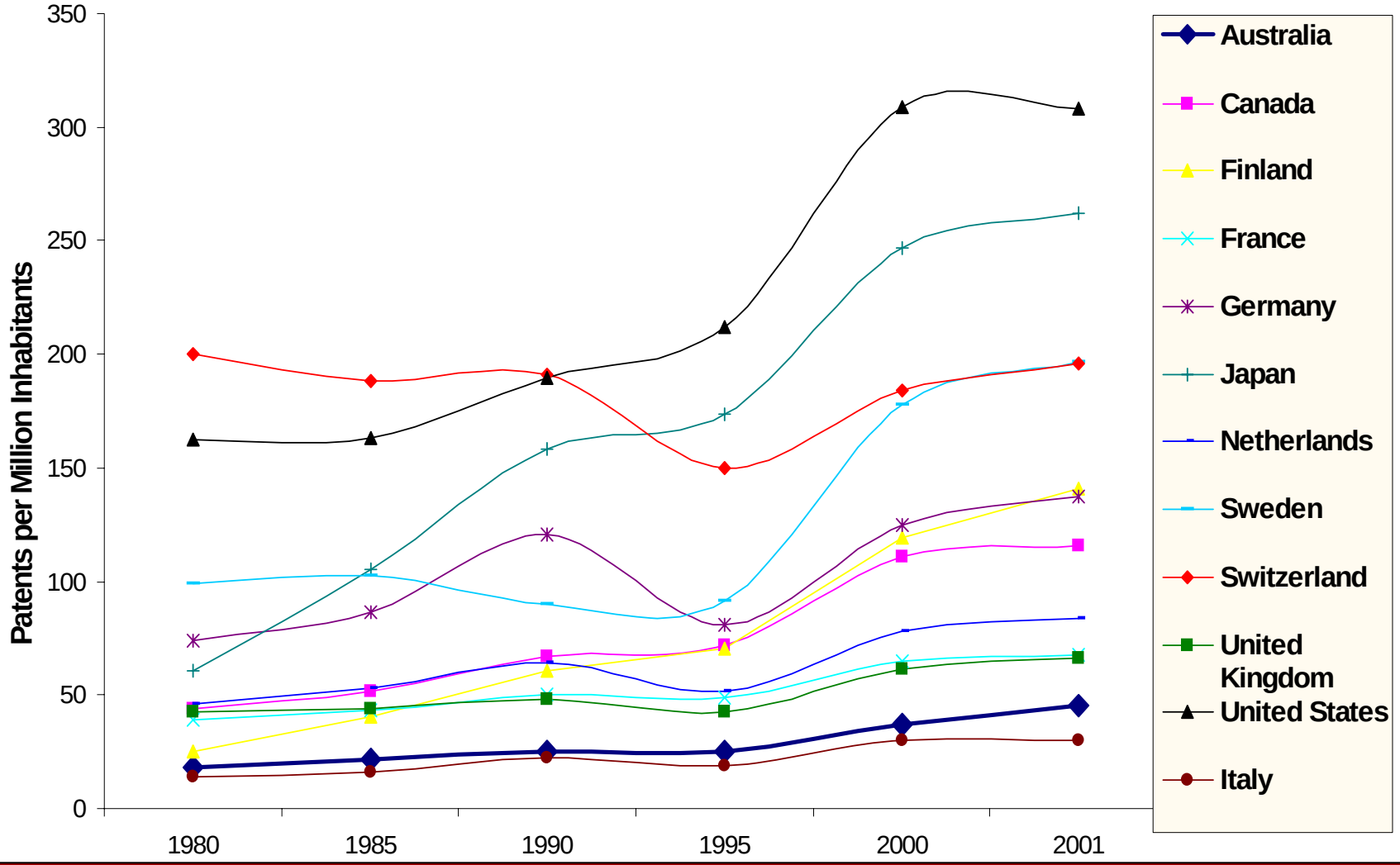
- Historically, new-to-the-world innovation has been concentrated in only a few locations
  - 1800s: UK → Germany
  - 1900s: USA & Switzerland
- Recently, sets of new countries have joined 'club' of world's leading innovators
  - e.g., Japan & Germany in 1970s & 1980s
  - e.g., Sweden & Finland, in 1990s
  - e.g., some Asian economies, Israel, Ireland in 2000s
  - *overall pattern of* ***convergence*** *(some catch-up)*
- Nonetheless, vast differences remain across countries and across regions within countries

New-to-the-World Innovation is Concentrated in a Small Number of Regions Around the World



Data are Patents Per Million Population (2002). ***Source: United States PTO***

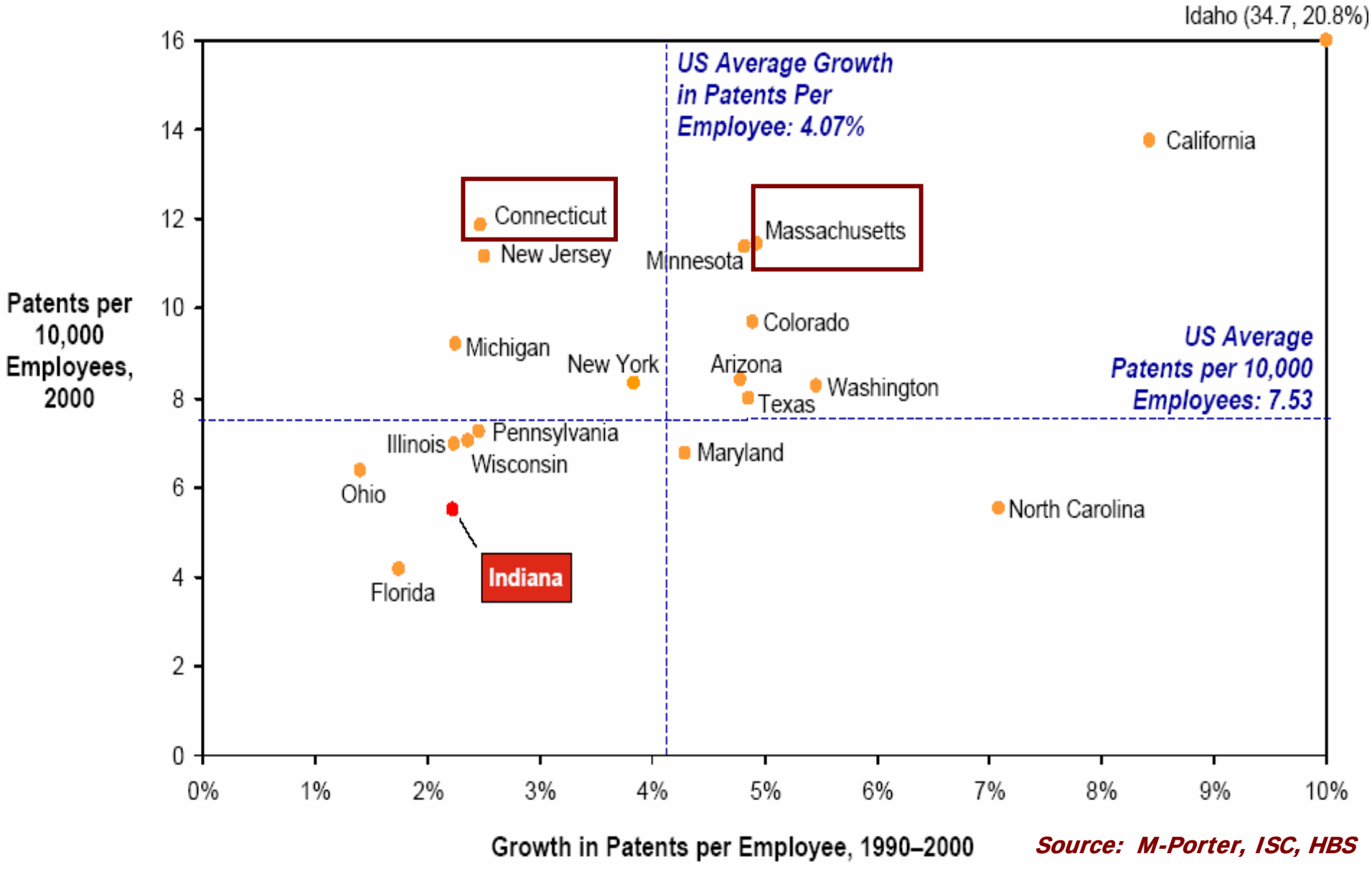
These differences have persisted historically, although a growing number of countries have joined the “innovator club”



Even with similar ***initial*** innovation rates, regions can diverge greatly in producing world-class technology...

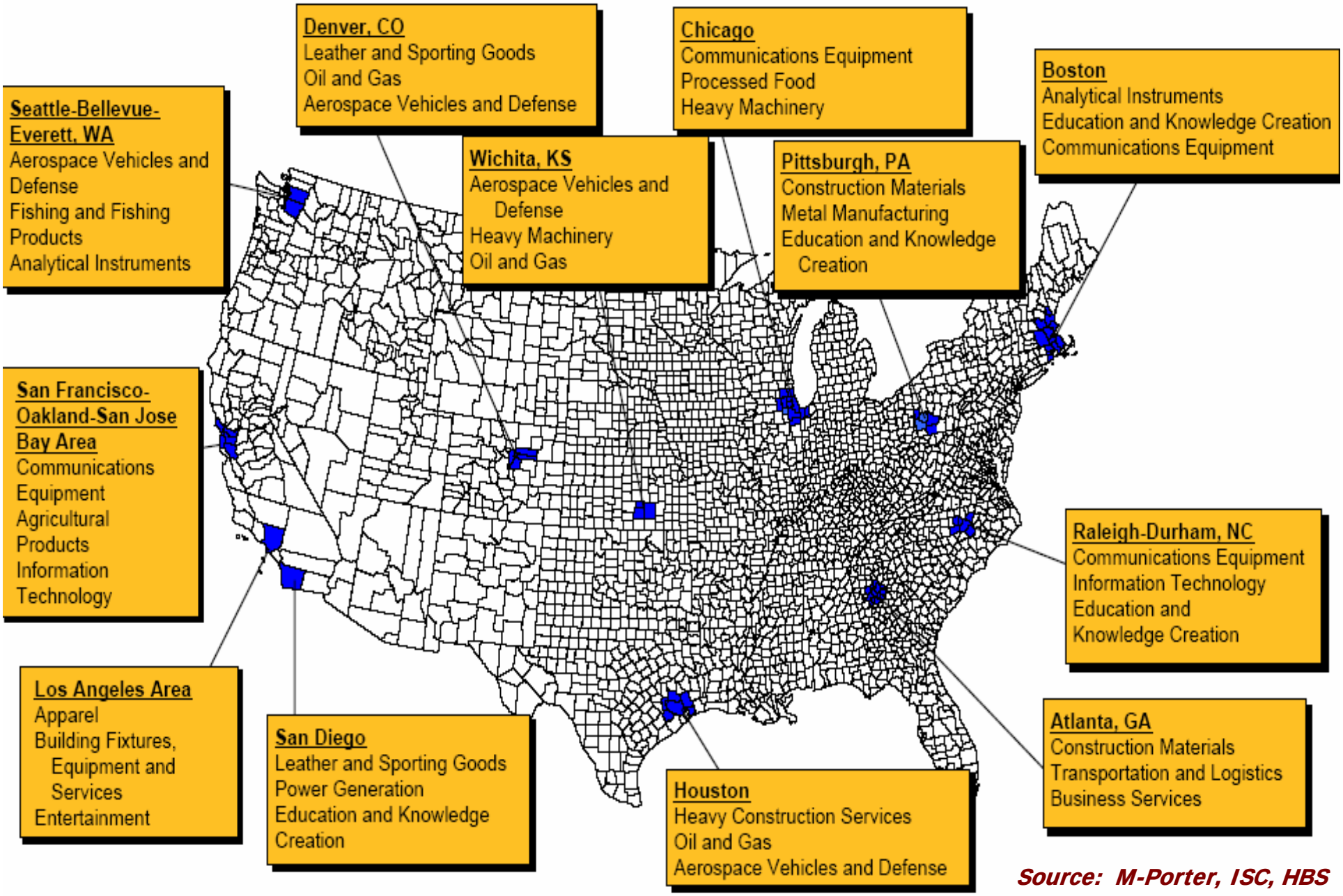
Country	United States Granted Patents		
	1976-1980	1995-1999	Growth Rate
Emerging Latin American Economies			
Argentina	115	228	0.98
Brazil	136	492	2.62
Chile	12	60	4.00
Costa Rica	22	48	1.18
Mexico	124	431	2.48
Emerging Asian Economies			
China	3	577	191.33
Hong Kong	176	1,694	8.63
Singapore	17	725	41.65
South Korea	23	12,062	523.43
Taiwan	135	15,871	116.56

Even within US, there are substantial differences across regions in terms of the intensity of innovation



Source: M-Porter, ISC, HBS

For a given industrial area, leadership is concentrated is a small number of regional locations within the United States



Source: M-Porter, ISC, HBS

What is Innovative Capacity?

- The potential for a region – as both a political and economic entity – to produce and commercialization a stream of innovation with potential global impact.

- Not simply the realized level of innovation, but the fundamental conditions, investments and policy choices that create the region's environment for innovation

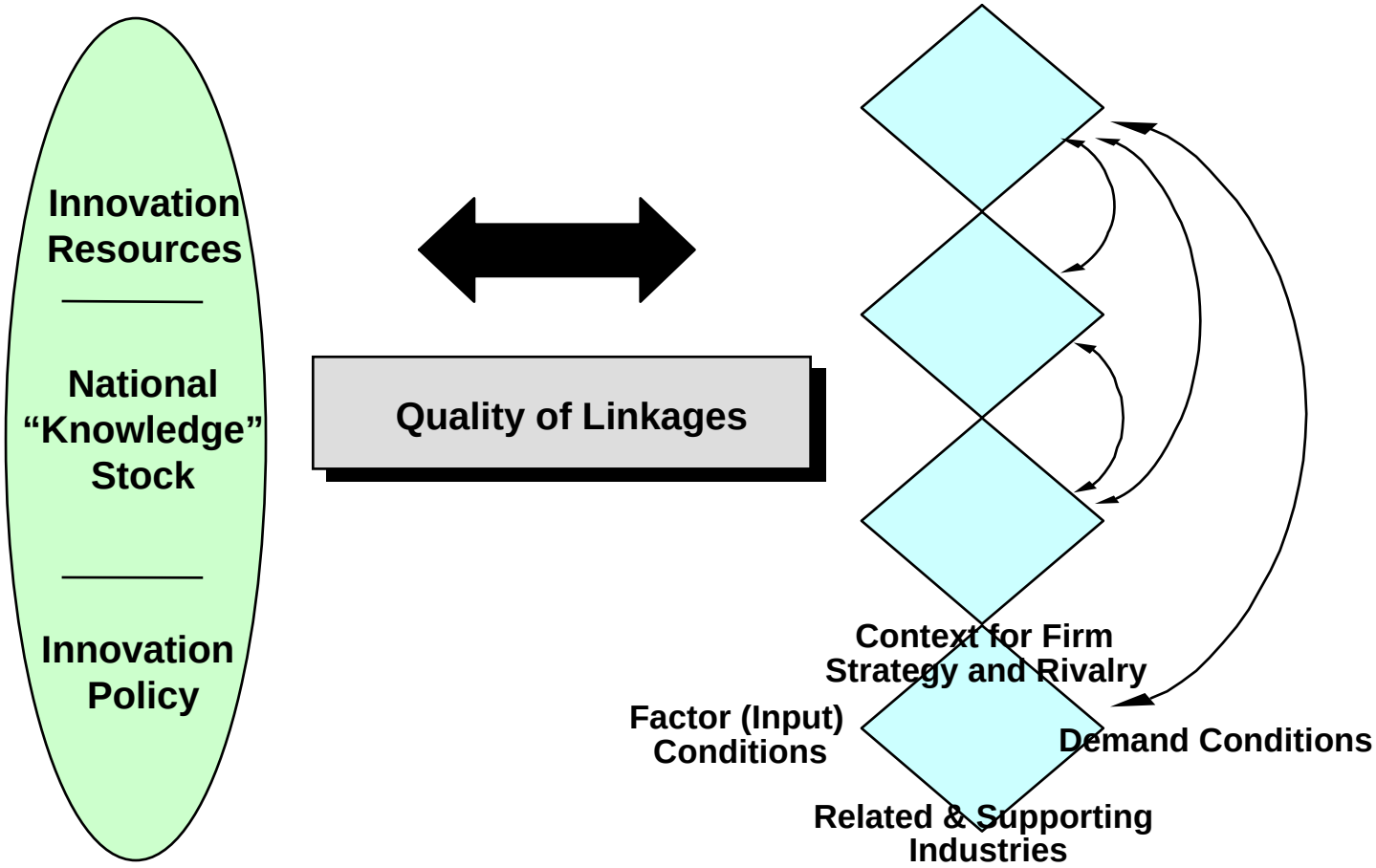
Relevant literatures: Standing on the shoulders of giants

- Ideas-driven growth theory *(Romer, 1990)*
  - endogenous growth theory *(macroeconomics)*
  - "production function for new ideas" depends on
    - stock of knowledge in economy and
    - level of R&D effort invested in production of new ideas
- National Industrial Competitive Advantage *(Porter, 1990)*
  - emphasizes microeconomic underpinnings of innovation in country-specific industrial clusters
- National Innovation Systems *(Nelson, 1993)*
  - rich descriptive accounts
  - emphasizes configuration of institutions and overall policy environment supporting innovation

The Drivers of Innovative Capacity

Common Innovation Infrastructure

Cluster-Specific Environment for Innovation



The Common Innovation Infrastructure

Innovation Resources

- Science & Engineering Workforce
- Access to Higher and Postgraduate Education
- Availability of Risk Capital
- High Quality of Information Infrastructure

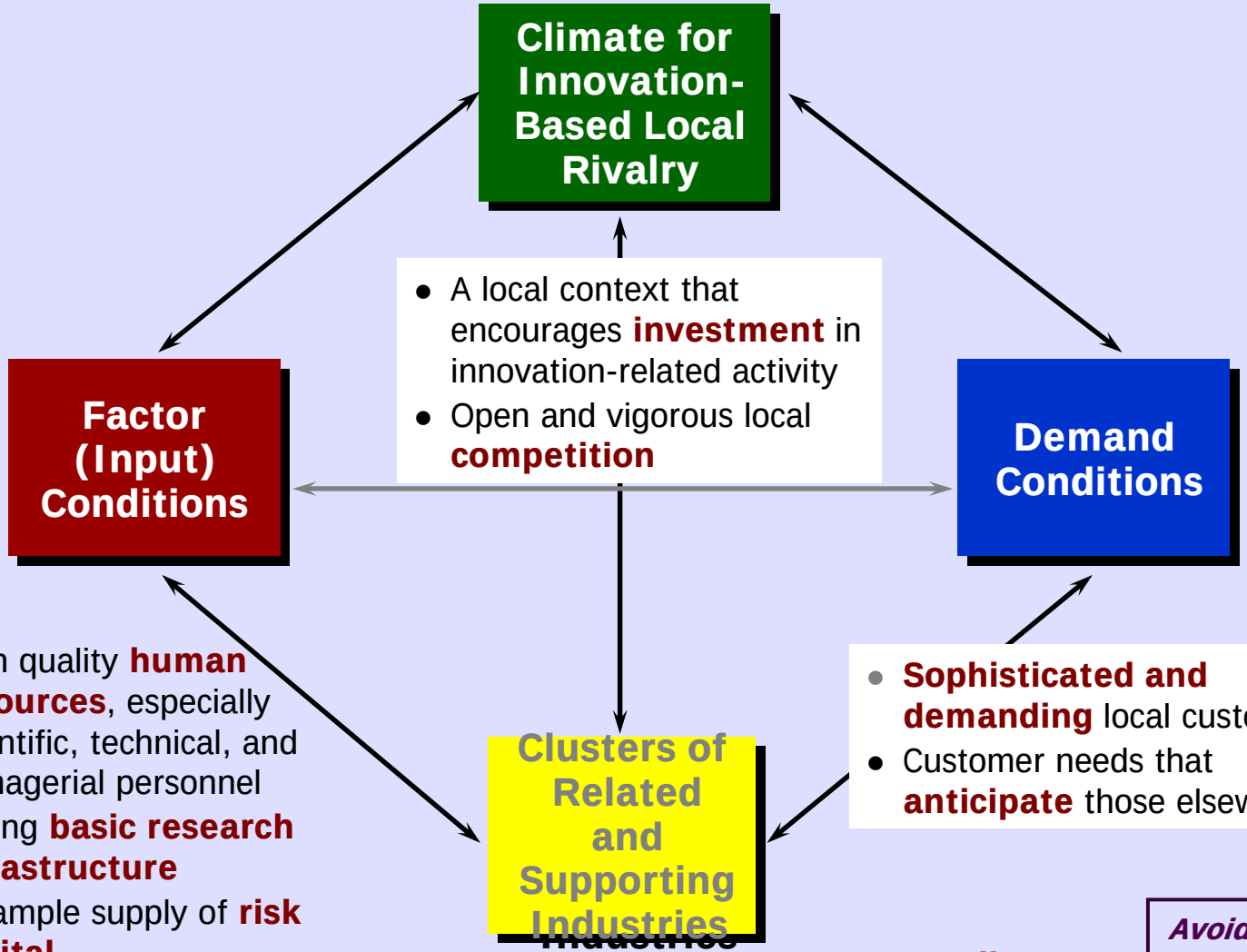
Innovation Policy

- Subsidy and Grant Programs
- R&D Tax Policy
- Education Policy & Funding
- Intellectual Property Protection Policy
- Openness to International Trade and Investment

National "Knowledge" Stock

- "Basic" Research Investments
- Cumulative Innovation Record
- Overall Technological Sophistication

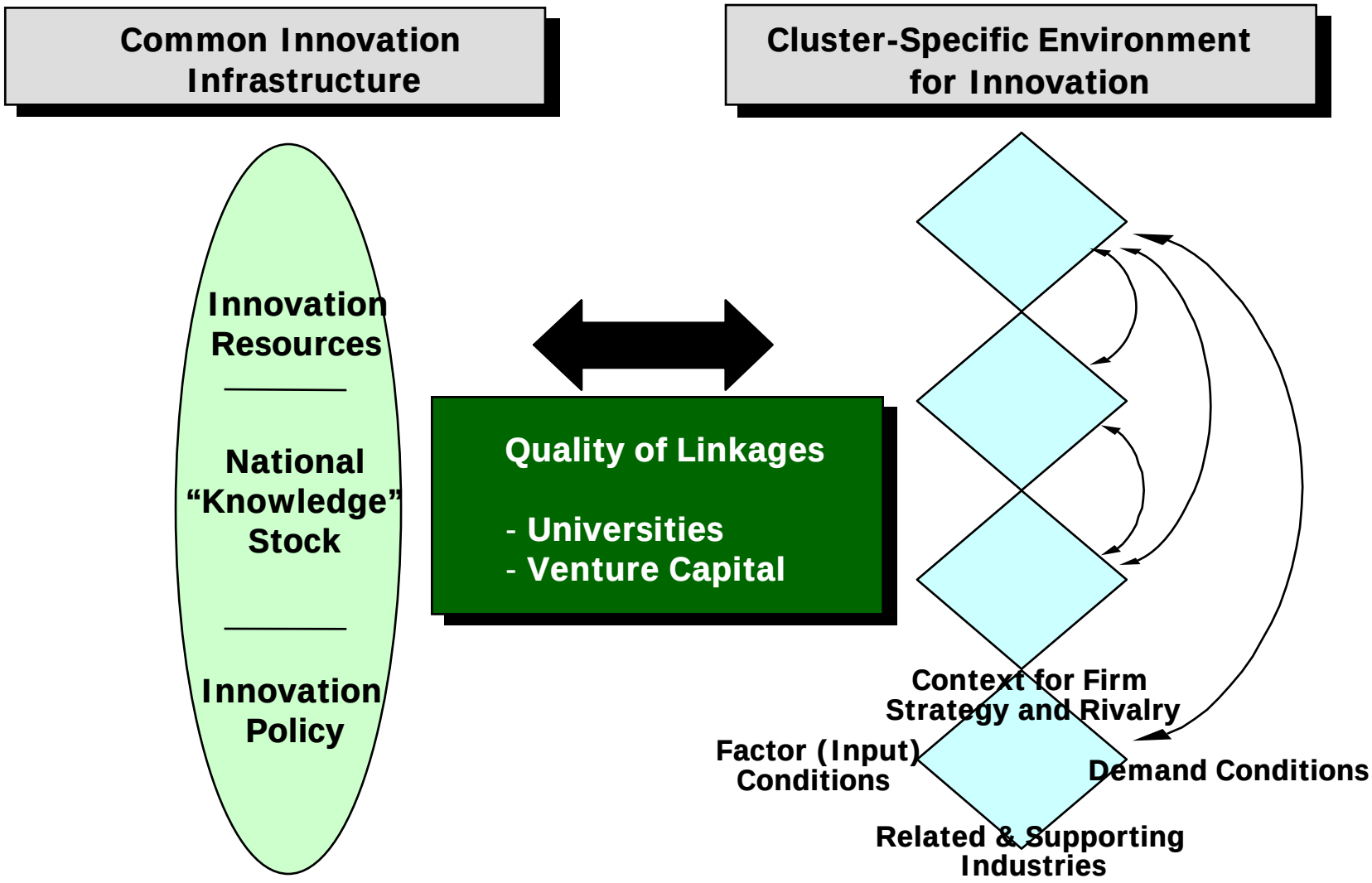
The Environment for Innovation in Industrial Clusters



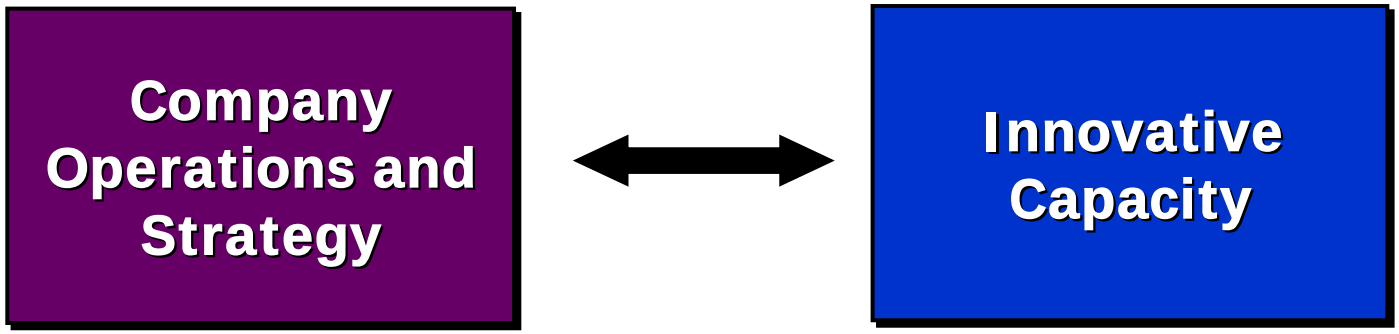
Avoid "picking winners" and "playing catch-up"

- Economic development is a process of **successive upgrading**, in which the business environment evolves to support and encourage increasingly sophisticated and productive **ways of competing**

Innovative Capacity Depends on Strong Linkages Between Solid Infrastructure & Dynamic Clusters



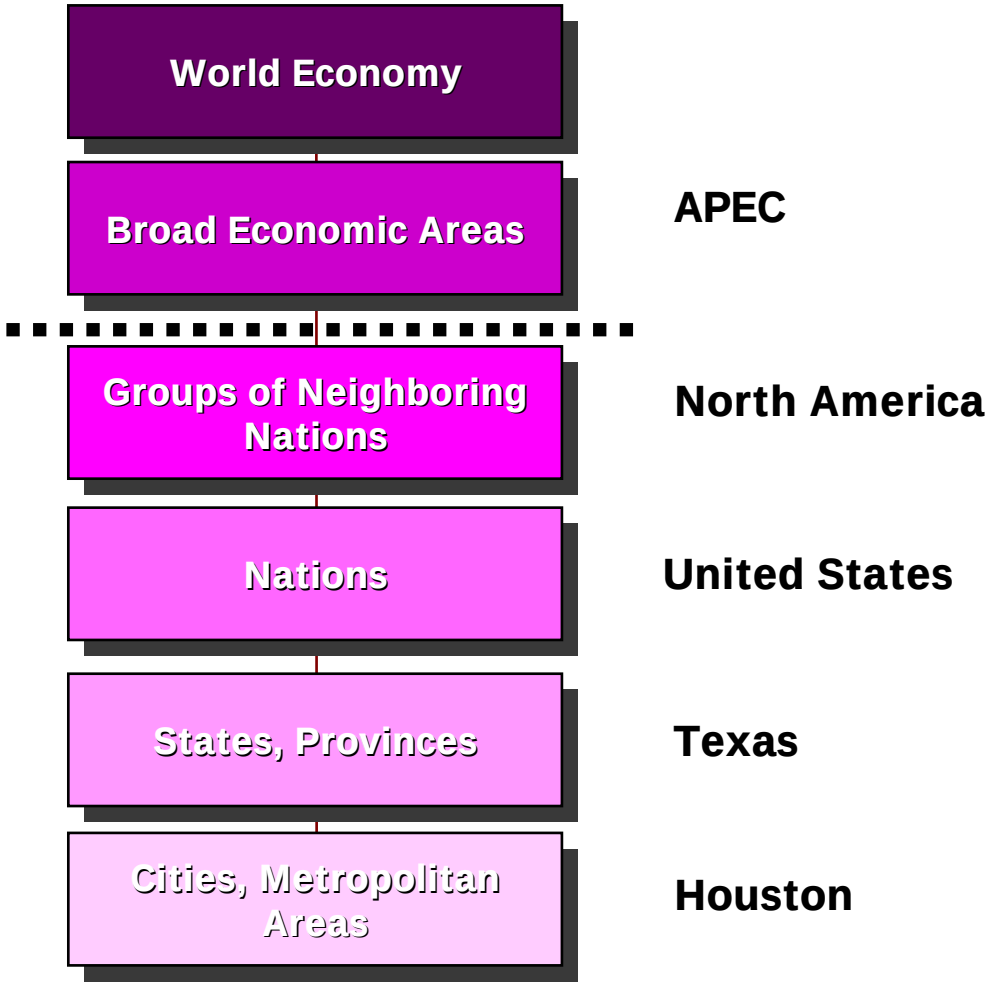
Finally, global innovation leadership results from leveraging local innovative capacity though effective and sophisticated firm operations and strategy



- Regional innovative capacity may be **squandered** through **ineffective innovation management**
- Innovation leadership **within a region** results from integrating external resources with internal capabilities

- R&D productivity depends on the **locations** at which a company's business units are based
- **Cluster participation** is an important contributor to innovative success

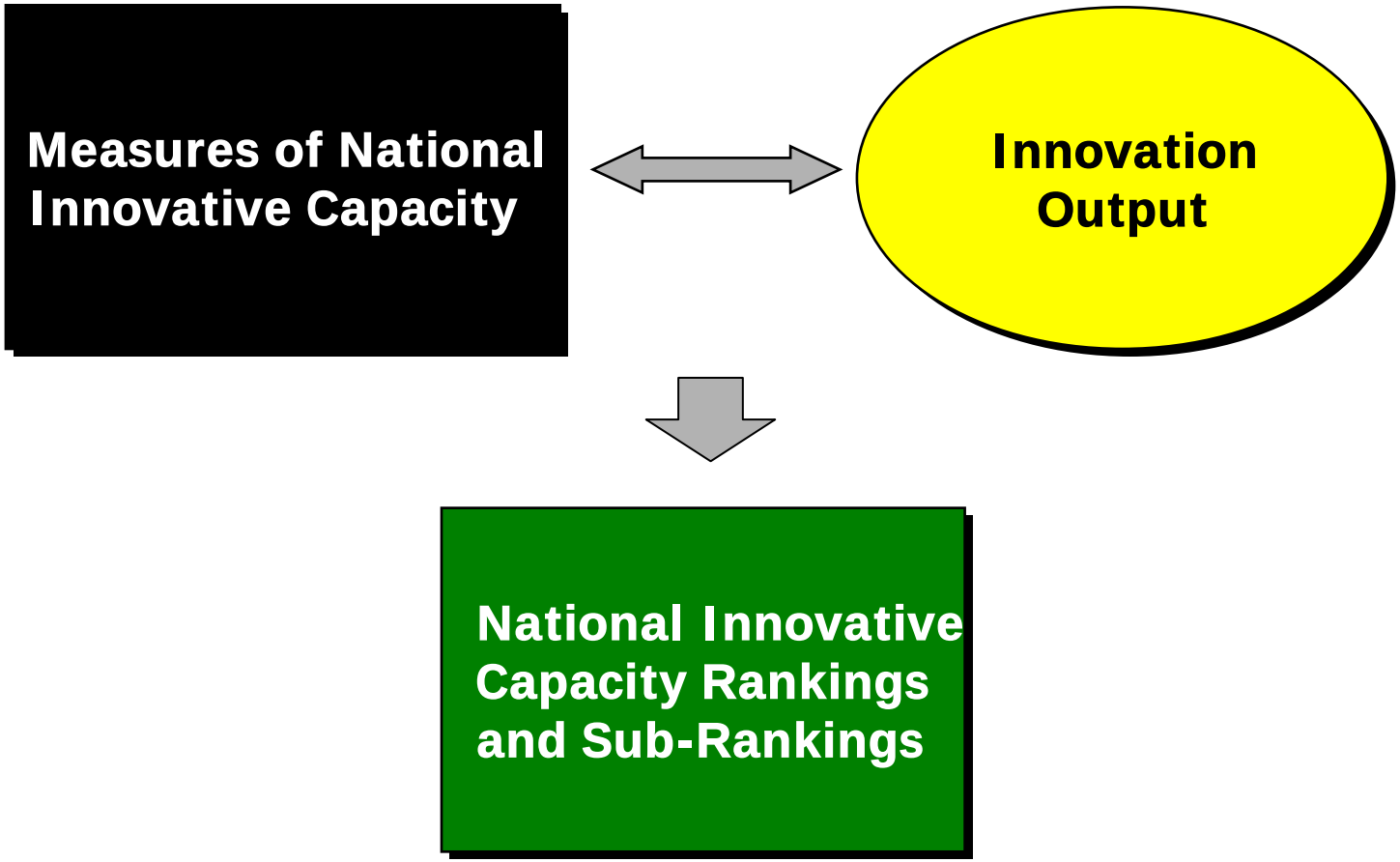
Innovation, Competitiveness & Geographic Levels



Assessing National Innovative Capacity

An objective, quantitative international benchmark of the *national* capacity for innovation

Methodology



Quantitative measures of National Innovative Capacity

Common Innovation Infrastructure

- Personnel employed in R&D
- Share of GDP spend on secondary and tertiary education
- Expenditures on R&D
- Strength of Intellectual Property Protection
- Openness to International Trade & Investment
- GDP per capita as a proxy for demand conditions and overall productivity

Cluster-Specific Conditions

- Percentage of R&D expenditures funded by Private Industry
- Specialization

Quality of Linkages

- Percentage of R&D performed by universities
- Venture Financing

Empirical Framework

- We estimate a modified "ideas production function"

$$(1)\ \dot{A}_{j,t} = \delta_{j,t}(X_{j,t}^{INF}, Y_{j,t}^{CLUST}, Z_{j,t}^{LINK}) H_{j,t}^{A\ \lambda} A_{j,t}^{\phi}$$

where in country *j*, at time *t*

$\dot{A}_{j,t}$ = flow of new-to-the-world technologies

$H_{j,t}^{A}$ = aggregate capital and labor devoted to R&D

X^{INF}, Y^{CLUS}, Z^{LINK} represent qualities of common infrastructure, clusters, and linkages, respectively

- The resulting econometric specification becomes

$$(2)\ L\dot{A}_{j,t} = \delta_{YEAR} Y_t + \delta_{COUNTRY} C_j + \delta_{INF} LX_{j,t}^{INF} + \delta_{CLUS} LY_{j,t}^{CLUS} + \delta_{LINK} LZ_{j,t}^{LINK} + \lambda LH_{j,t}^{A} + \phi LA_{j,t} + \varepsilon_{j,t}$$

Data and Measures

- Panel dataset, *1978-1999*
  - Core dataset = 23 countries; *expanded dataset = 29*
  - *Sources:* CHI Research, OECD, NSF, World Economic Forum, Penn World Tables

- Measuring national innovative output
  - ***"International Patents" =*** number of patents granted by United States Patent & Trademark Office to a county's inventors
  - while no measure is ideal, "international patents"...
    - reflect important fraction of overall innovation
    - measure economically significant innovations at the world's technological frontier
  - to reflect lag, analysis uses patents in time *t+2*

Measuring the drivers of national innovative capacity

- Quality of the Common Innovation Infrastructure
  - GDP per Capita
  - Number of R&D Personnel
  - R&D Expenditures
  - Share of GDP Spent on Higher Education
  - Strength of Intellectual Property Protection
  - Openness to International Competition and Trade
- Environment for Innovation in Industrial Clusters
  - % of R&D Funded by Private Firms
  - Specialization
- Strength of Linkages
  - % of R&D Performed by Universities
  - Availability of Financing for New Ventures

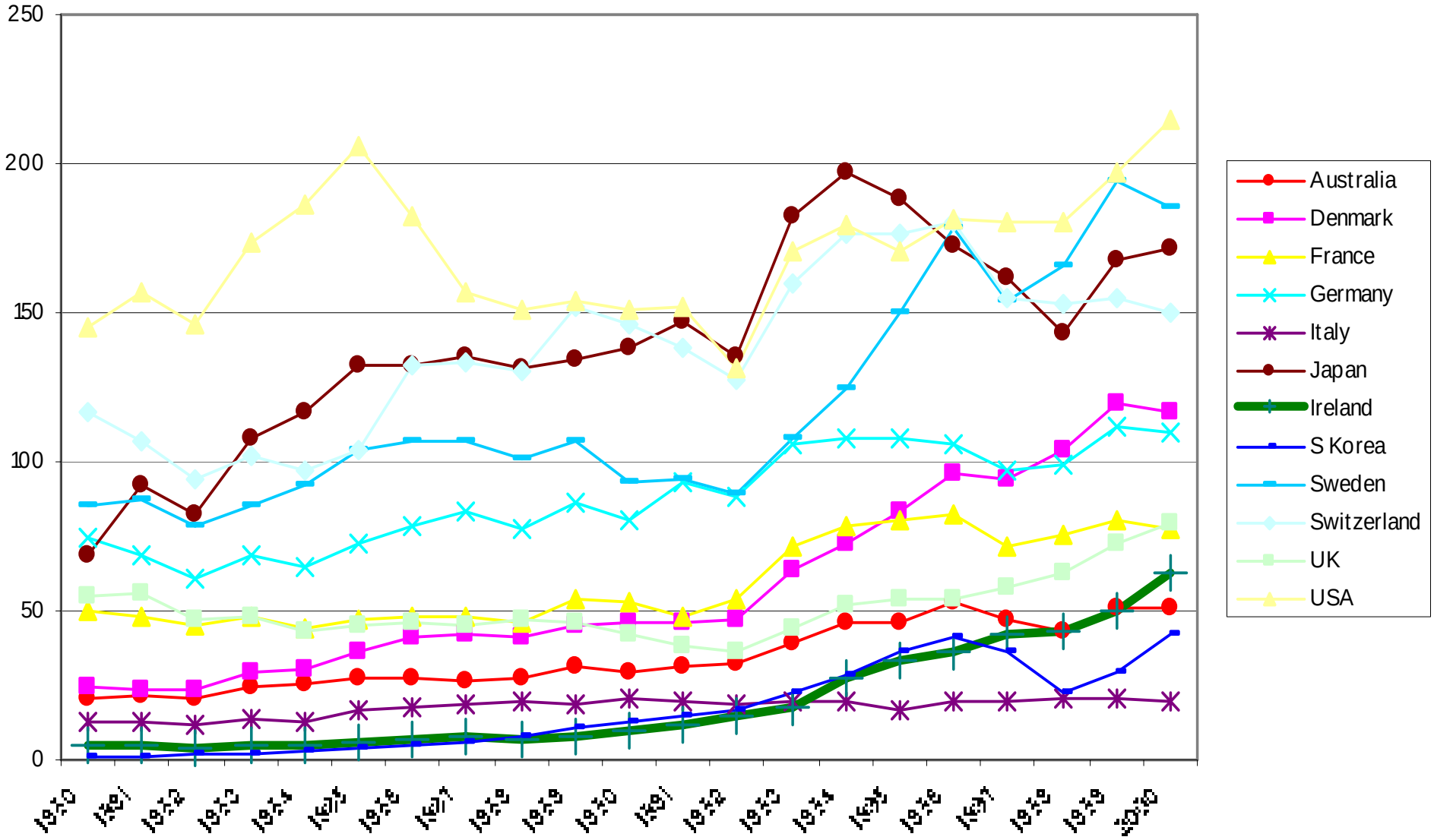
Result I: A parsimonious number of factors predict new-to-the-world innovation precisely

- Small # of factors explain nearly all of variation in national innovative output
  - i.e., the factors in our empirical model
- The innovative capacity *index* is closely tied to important economic measures
  - productivity (TPF)
  - economic growth (GDP)

		Dep. Var. = $\ln(\text{PATENTS})_{j,t+2}$
COMMON INNOVATION INFRASTRUCTURE		
A	L GDP PER CAPITA	**0.836**
A	L GDP78	**-0.289**
H_A	L FT R&D PERS	**0.850**
H^A	L R&D $	**0.556**
X^{INF}	ED SHARE	**0.089**
X^{INF}	OPENNESS	**0.0018**
CLUSTER-SPECIFIC INNOVATION ENVIRONMENT		
Y^{CLUS}	PRIVATE R&D FUNDING	**0.012**
QUALITY OF THE LINKAGES		
Z^{LINK}	UNIV R&D PERFORMANCE	**0.011**
CONTROLS: Year Fixed Effects, US dummy		
R-Squared		*0.9973*
Observations		*473*

The Innovation Index for selected countries

(Index computed as expected patents per capita based on regression analysis)



Result II: Innovator countries can be usefully categorized into four groups

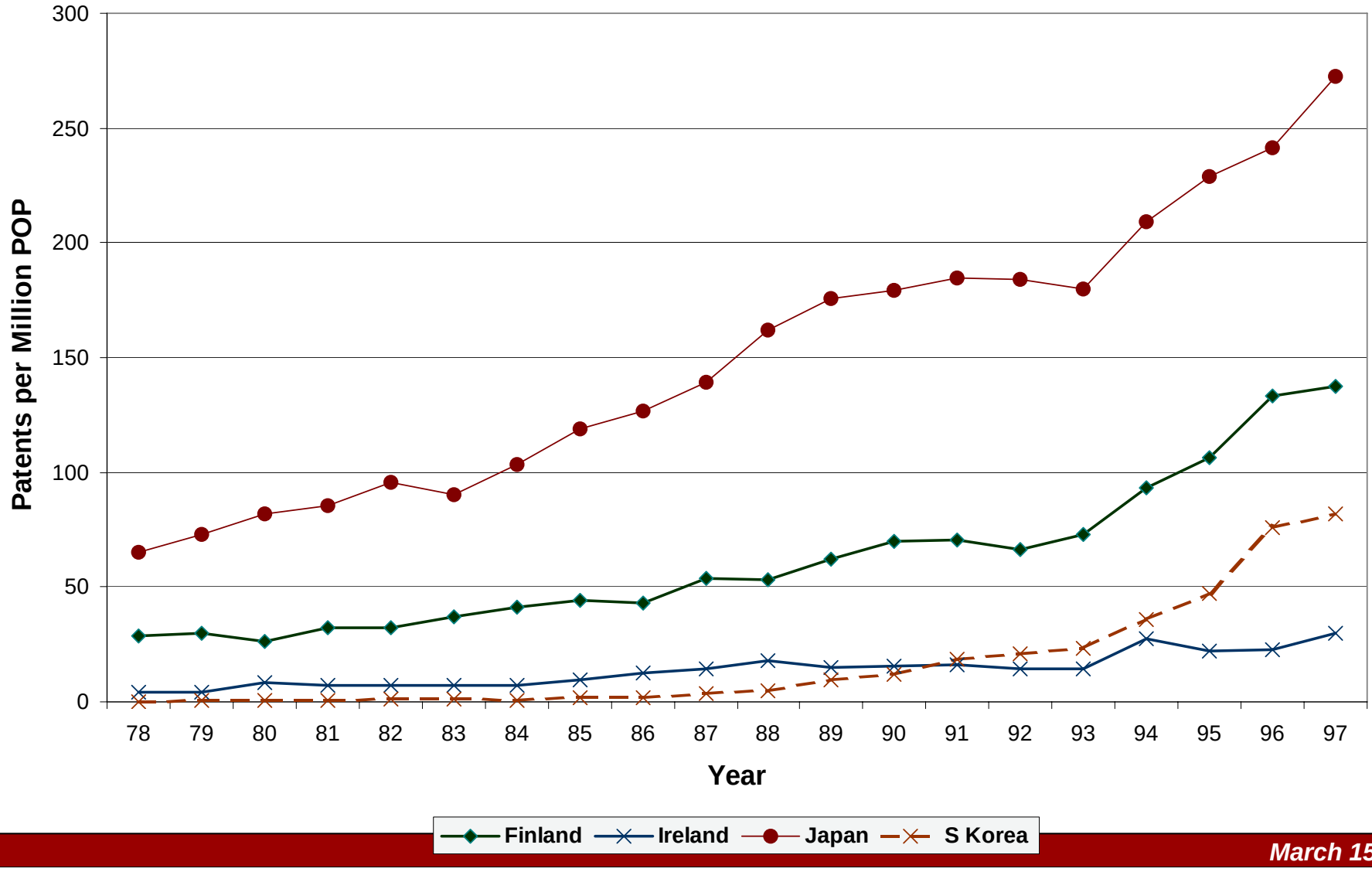
- **Leading innovators**
  - consistently high level of innovative capacity; increasing commitments to R&D inputs and policies
- **Middle tier**
  - relatively stable or slightly improving levels of innovative capacity
- **Third tier**
  - consistently low absolute levels of innovative capacity; potentially high relative catch-up
- **Emergent innovators**
  - initially lower levels of innovative capacity, increased dramatically by investments drivers of innovation

Categorizing Innovator Countries

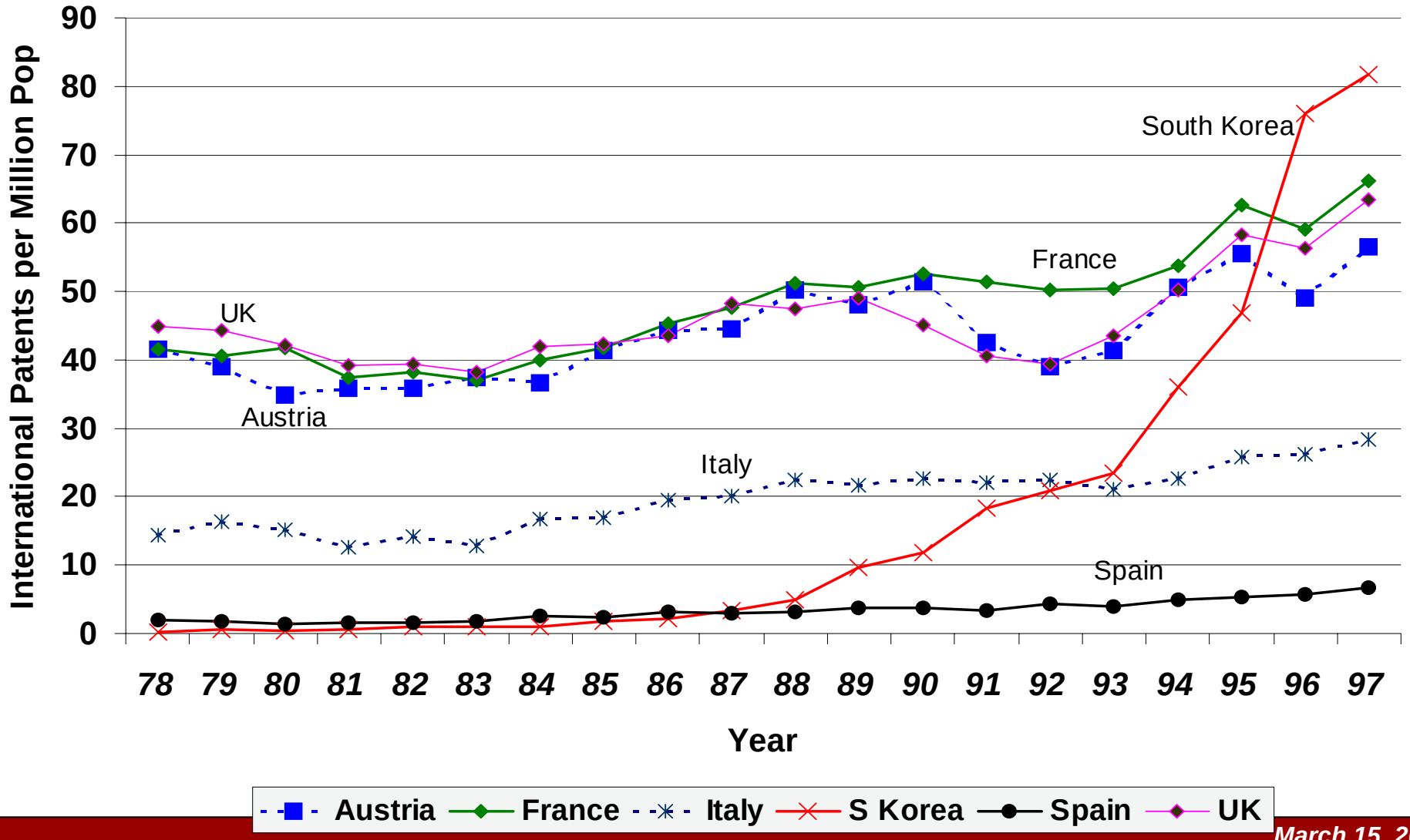
Leading Innovator	Middle Tier	Third Tier	Emerging Innovator
Germany	Austria	Greece	Denmark
Japan	Australia	Italy	Finland
Sweden	Belgium	New Zealand	Iceland
Switzerland	Canada	Portugal	Ireland
USA	France	Spain	South Korea
	Netherlands		Israel*
	Norway		Singapore*
	UK		Taiwan*

** Countries in grey not included in full data analysis because of data availability.*

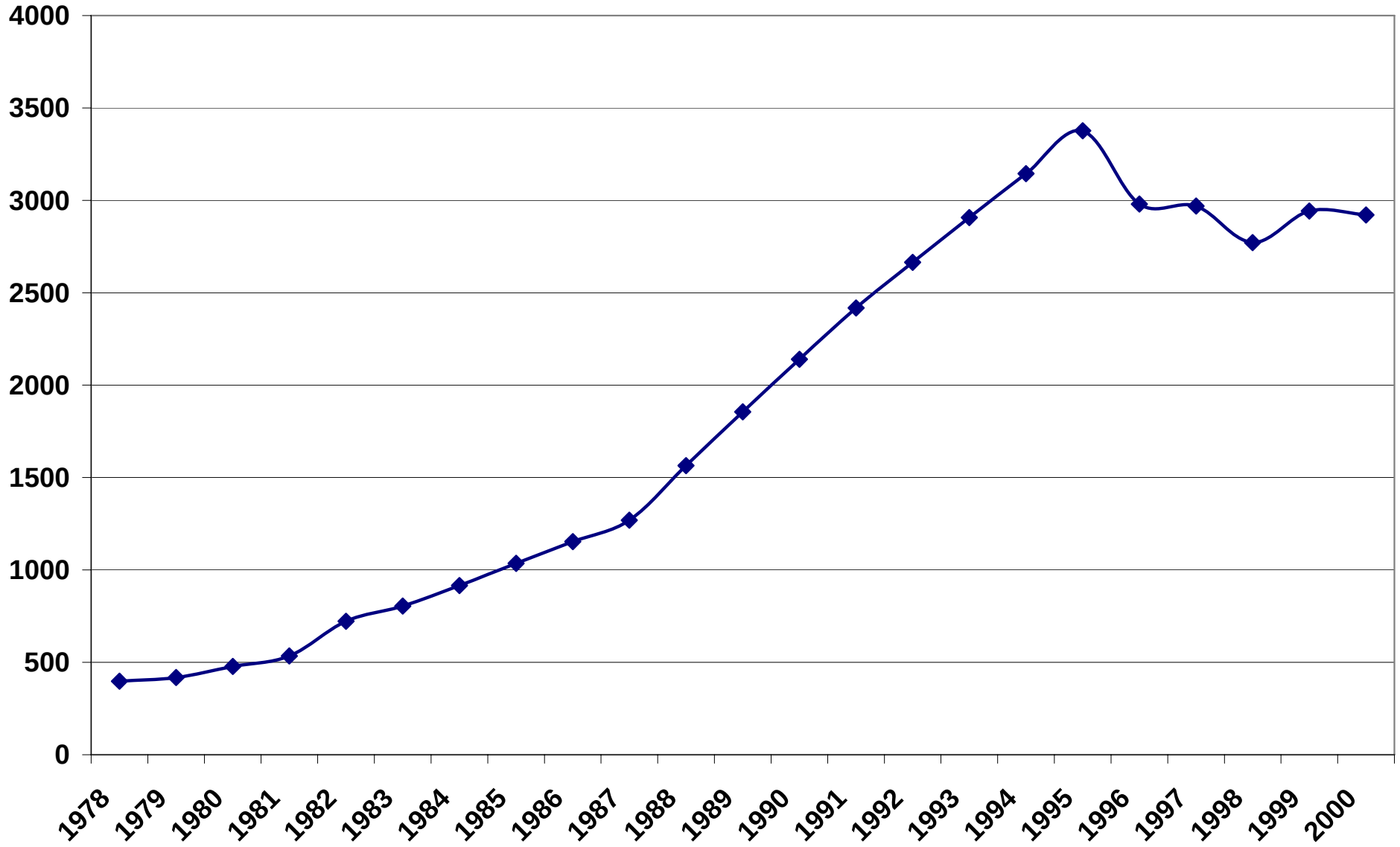
PATENTS per million persons: Emerging Innovator Countries (& Japan)



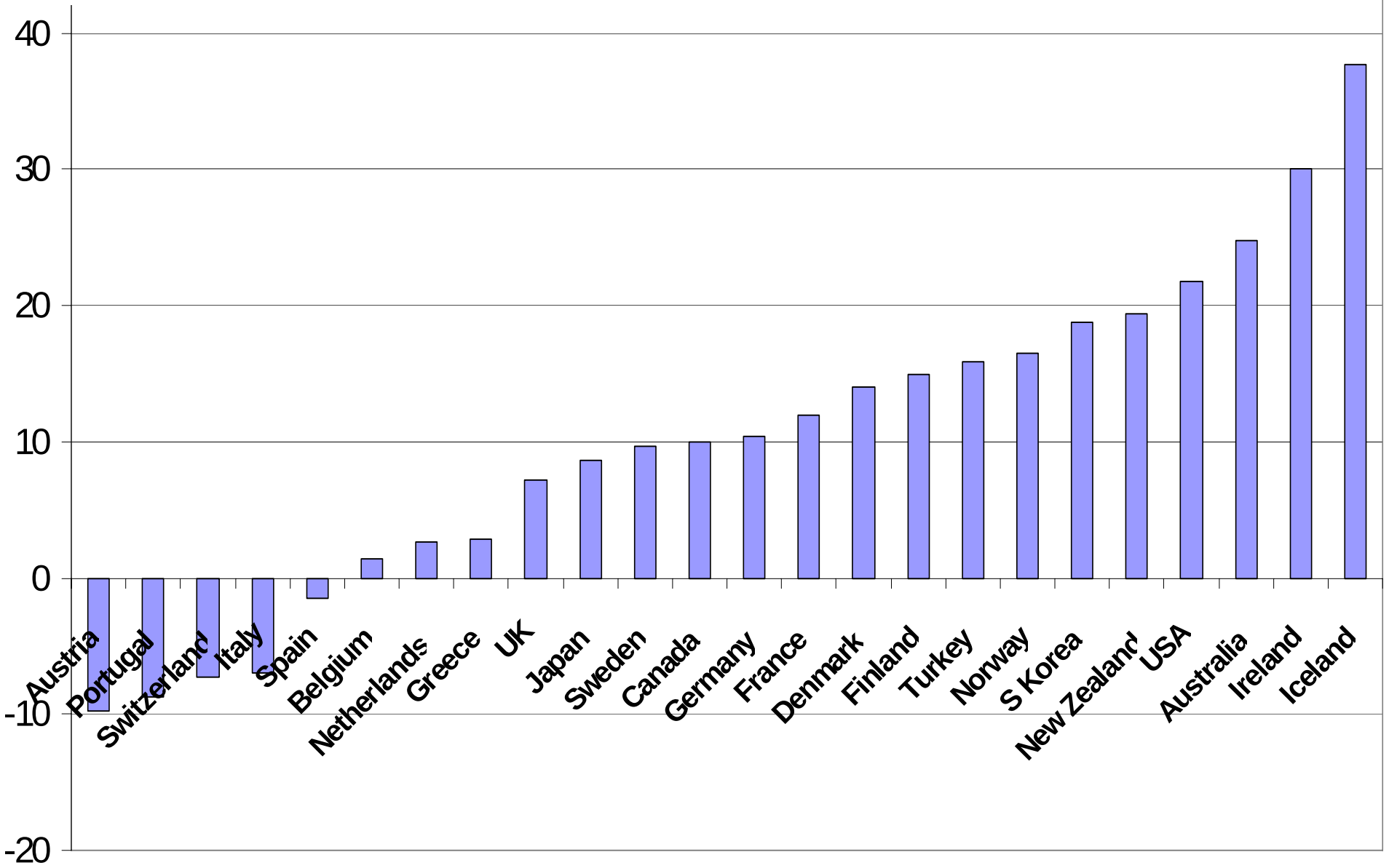
PATENTS per million persons: Third Tier Countries + S. Korea



R&D workers per million people – South Korea (1978-2000)



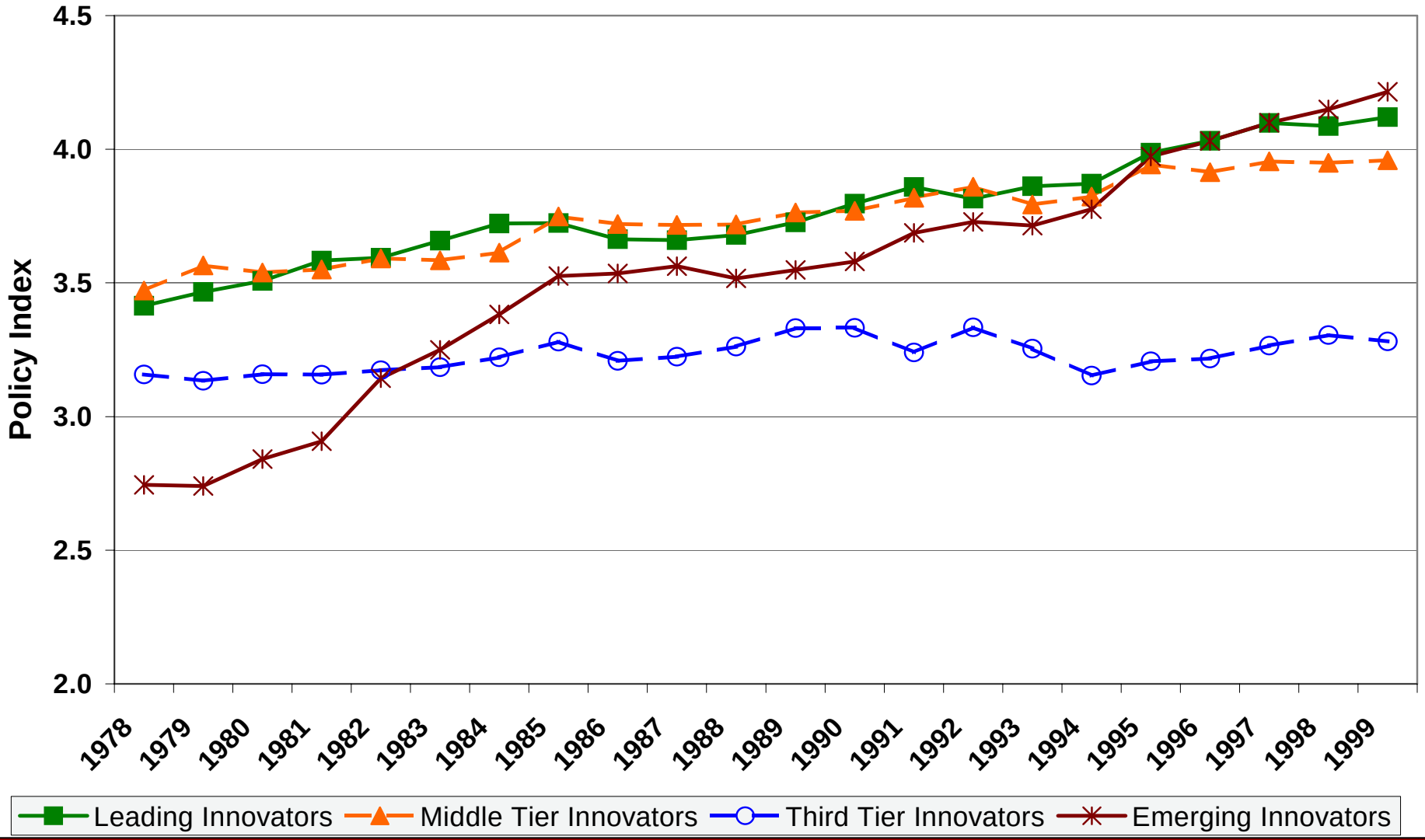
Change in Percentage of R&D Financed by Industry (1978-1999)



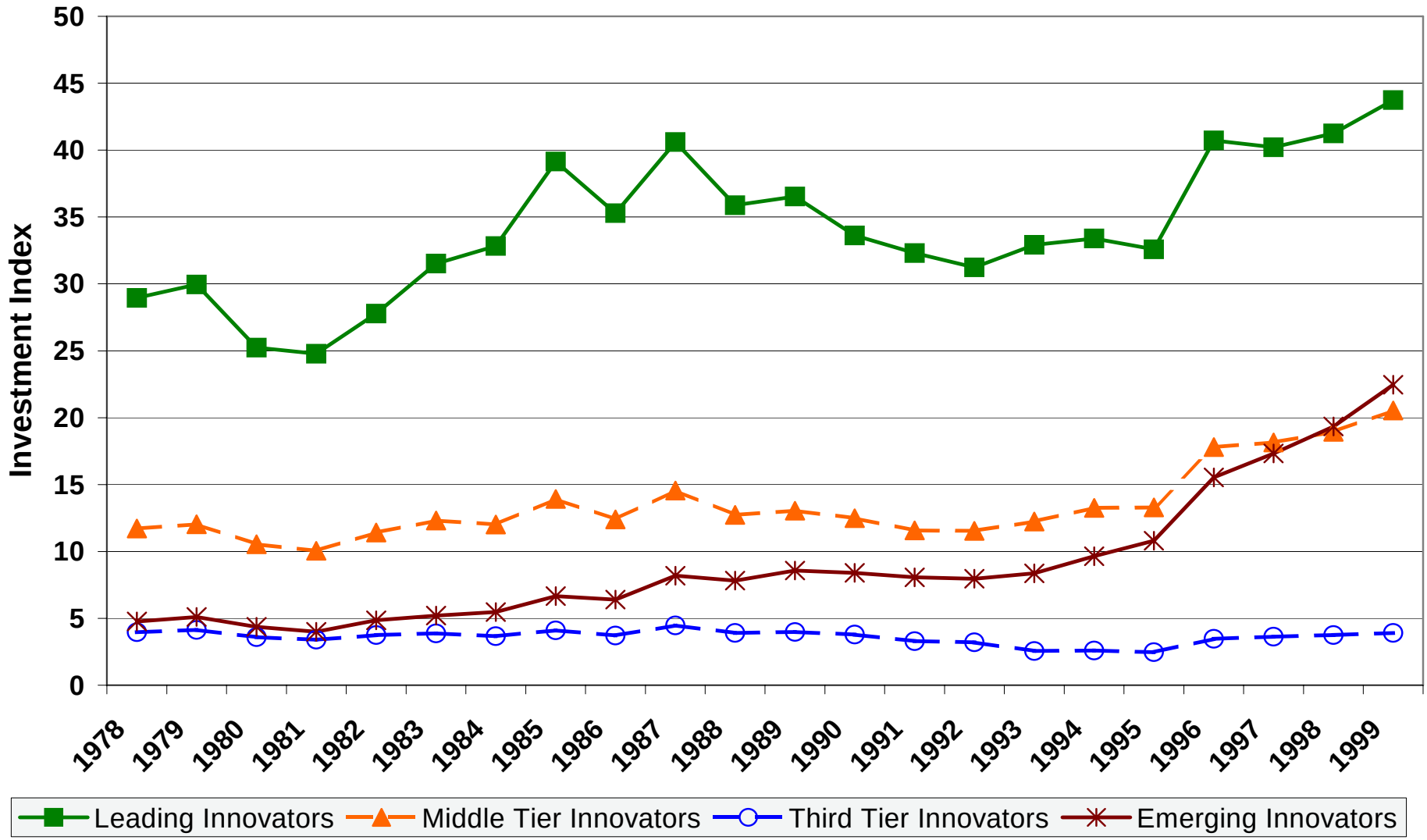
Disentangling sources of national innovative productivity

- Use determinants of actual patenting to construct **indices**
  - weights in index determined by coefficients in preferred innovation production function model
- **Policy / Innovation System Index** ***(X, Y, Z)***
  - *= actual policy/levels of policies * coefficients*
    - (1) % R&D Expenditures Financed by Industry
    - (2) % R&D Expenditures Performed by Universities
    - (3) % of GDP devoted to Higher Education
    - (4) Openness of economy to international competition
- **Investment Index** ***(A & H)***
  - *= levels of investment in innovation*coefficients (corrected for POP)*
    - (1) GDP
    - (2) GDP PER CAPITA
    - (3) R&D Expenditure
    - (4) Scientist & Engineer Employment

Policy/System Index



Investment Index



Result III: Emerging innovators raise their level of innovative productivity

- By *continuously* increasing investments in innovation
  - differences across groups substantial
  - emerging innovator countries overtake middle tier
  - middle & bottom tiers do not substantially increase commitments to innovation over period; leading innovators *relative position* declines if investments lag
- As well as by improvements in policies and innovation system characteristics
  - differences across groups not as pronounced
  - initial levels substantially below those of continuous innovator, middle tier & bottom tier
  - final levels equal to continuous innovators & middle tier

Implications of country-level analysis

- The ability to innovate at the world technological frontier can be explained *(precisely!)* by a parsimonious set of factors
- Catch-up is real: Emerging innovator countries are improving innovative output per capita, as a result of both
  - *continuously upgrading investments in innovative capacity*
  - *adopting innovation-oriented policies*
  - as a consequence, the generation & exploitation of new-to-the-world innovation is becoming less geographically concentrated
- ***There is, however, no one magic bullet, either to achieve or maintain innovative leadership***
  - *continuous upgrading is essential for maintaining leadership*
  - *those countries that 'rest on laurels' are being overtaken*
  - *sound public policy appears capable of playing a positive role in shaping national innovative capacity*

Implications for firms & industries

- Supporting investments in innovation and pro-innovation policies may have both specific and general positive effects
  - specific benefits may accrue from supporting sustained investment in drivers of industry/sector-level innovation
    - e.g., research consortia, R&D/technical training, ...
  - general benefits from common innovation infrastructure
    - e.g., availability of highly-talented employees; overall innovation policy
  - mix of benefits from linkages between them
    - e.g., access to application-oriented university research
- Choice of location is important!
  - locations that support innovation and where spillovers are potentially available from own sector or relevant other industrial clusters are particularly desirable
  - low cost environments not necessarily conducive to innovation
  - that said, the # of attractive locations is increasing!

Thank you!!!

- Thank you again for your time & consideration
- I hope you enjoyed the Breakfast
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