Knowledge Production and Role of Higher Education in Innovation and Development

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OUTLINE

Worldwide expansion of higher education

Knowledge spillover and innovation

Triple Helix Model of innovation

Measuring university-industry-government linkage

WORLDWIDE EXPANSION OF HIGHER EDUCATION

Schofer & Meyer (2005) Worldwide expansion of higher education

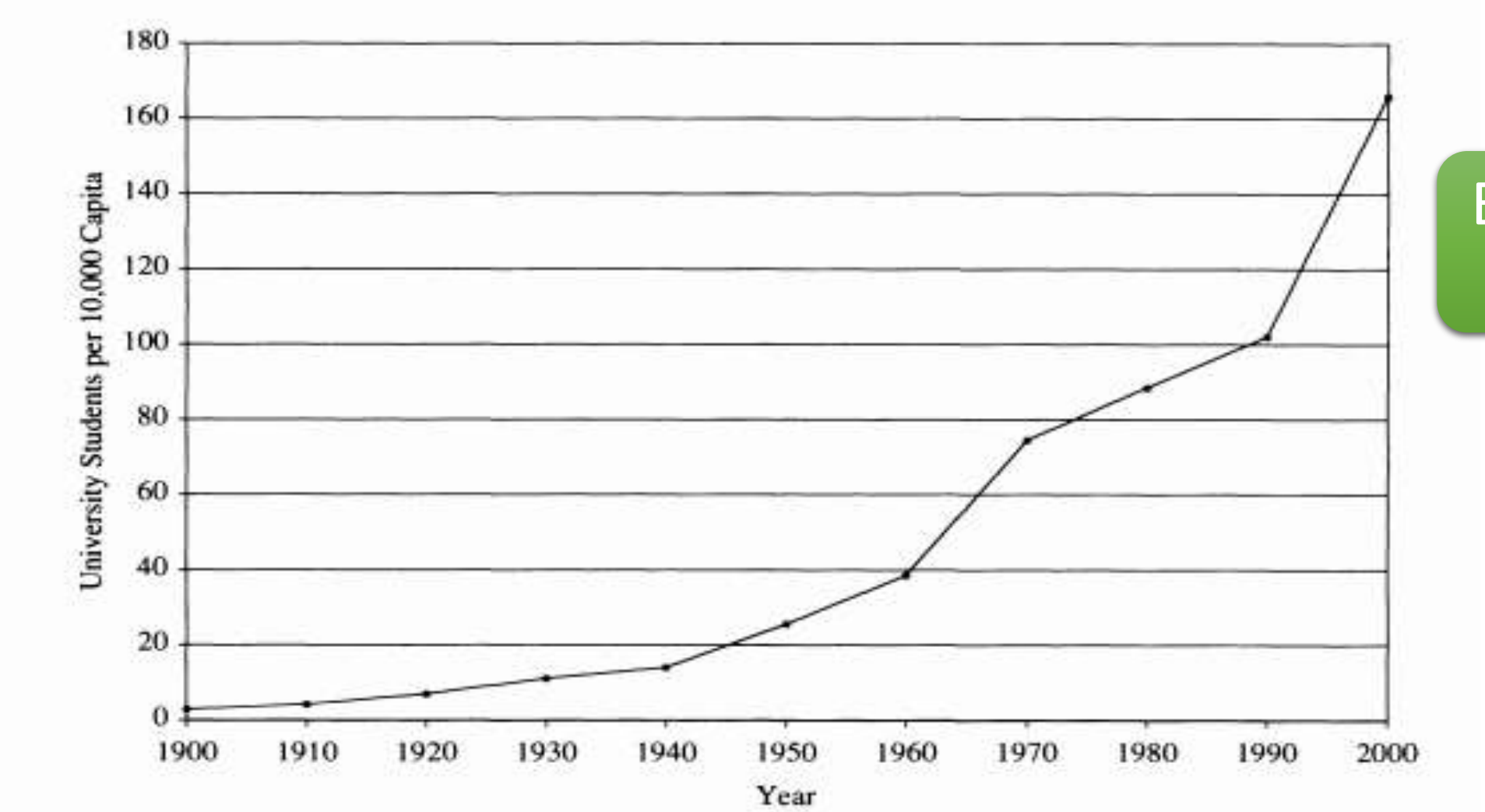

Figure 1. World Higher-Education Students per 10,000 Capita, 1900–2000.

Enrollment expansion

Schofer & Meyer (2005) Worldwide expansion of higher education

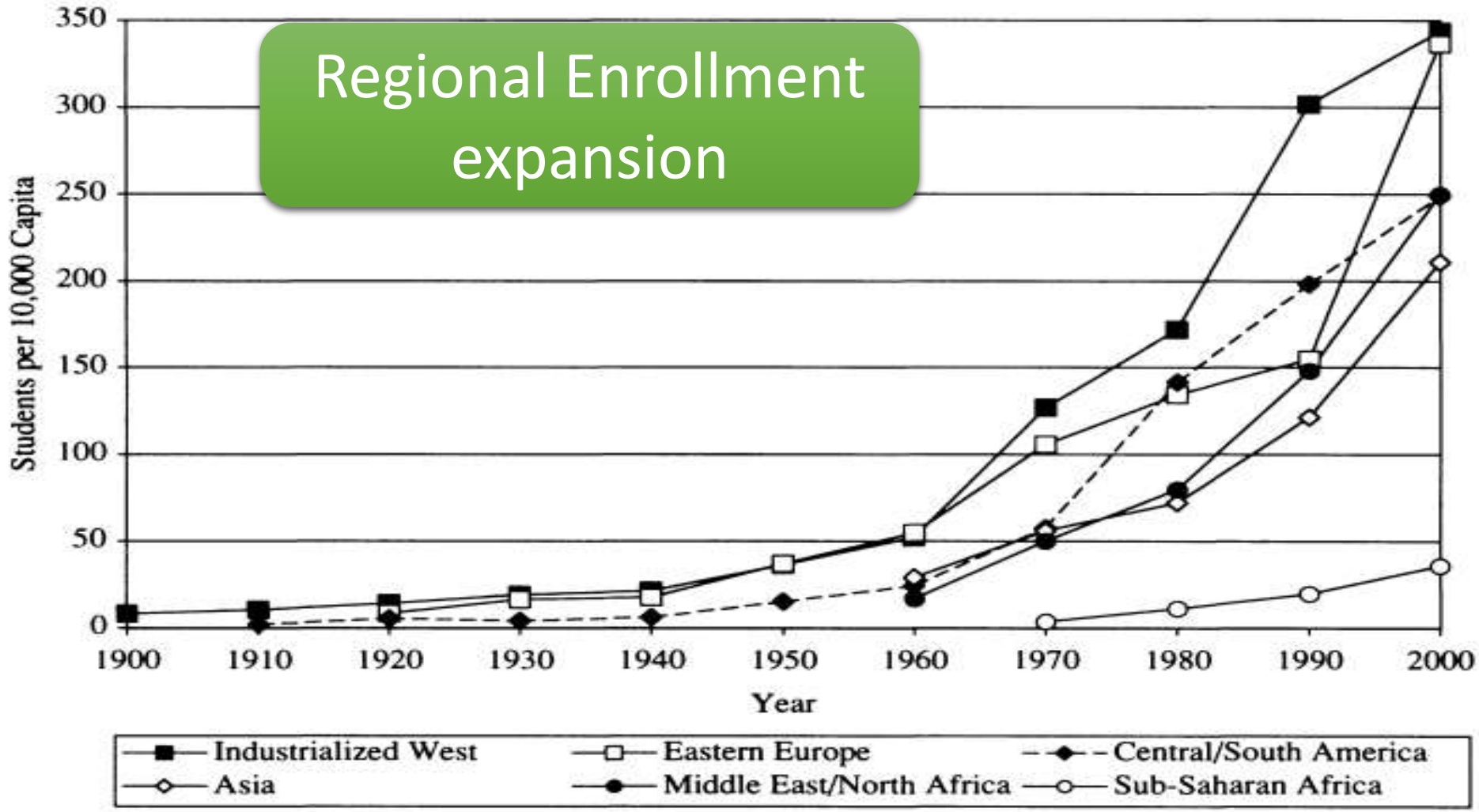

Figure 3. Tertiary Students per Capita, Regional Averages, 1900–2000 (constant cases).

Schofer & Meyer (2005) Worldwide expansion of higher education

Drivers of Enrollment expansion

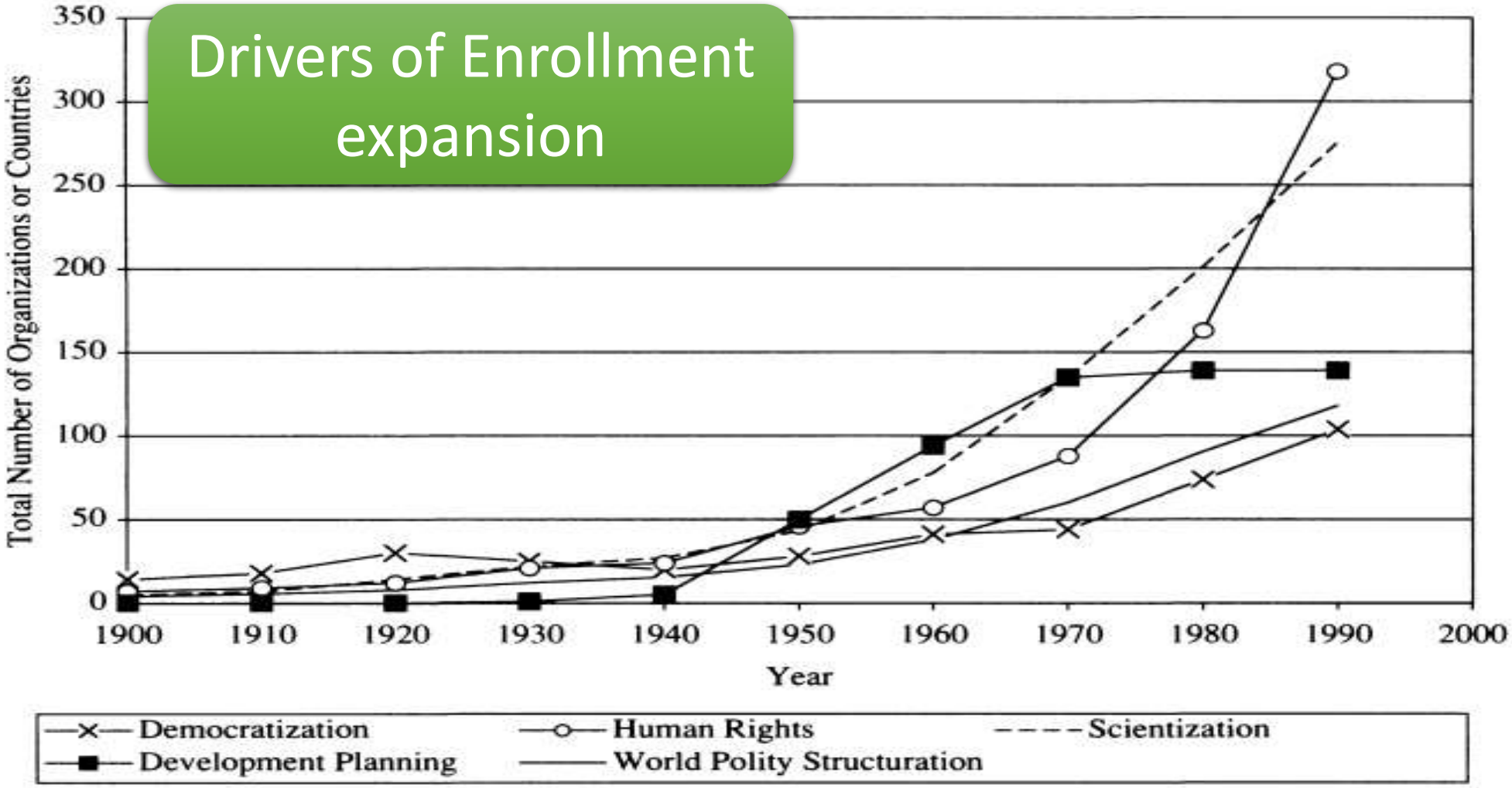

Figure 2. World Polity Trends Supporting the Expansion of Higher Education.

Note: World polity structuration measure divided by 100 to fit scale.

Scientific performance of university

- **Centre for Science and Technology Studies (Leiden University)** released the 2018 edition of the Leiden Ranking. The CWTS Leiden Ranking 2018offers important insights into the scientific performance of 938 universities from 55 different countries. The CWTS Leiden Ranking 2018 is based on Web of Science indexed publications from the period 2013–2016

Scientific performance of university

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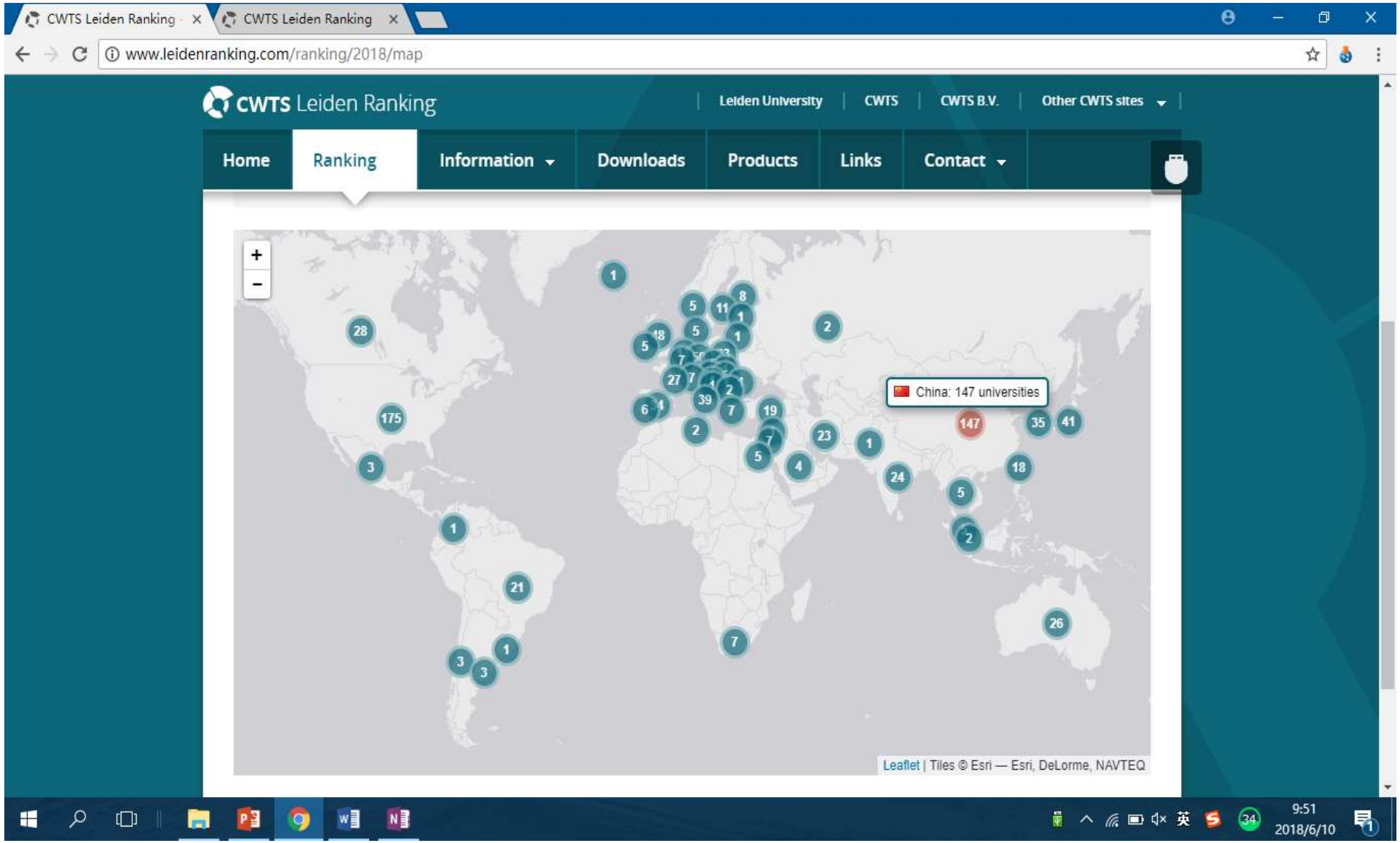
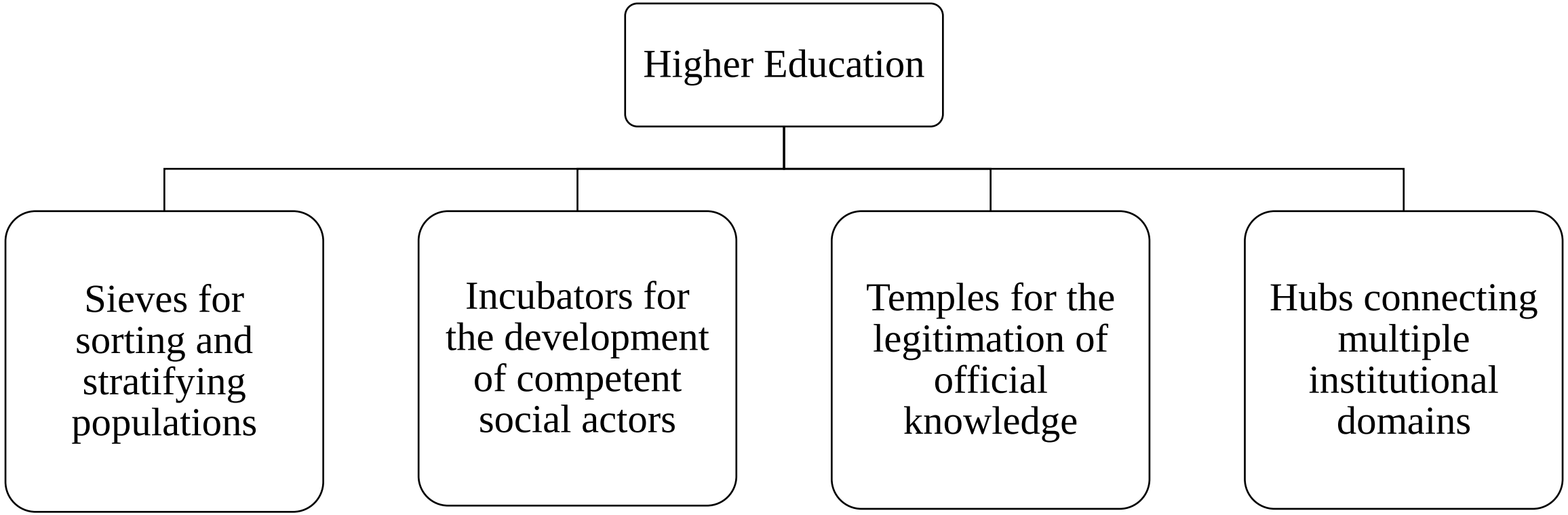
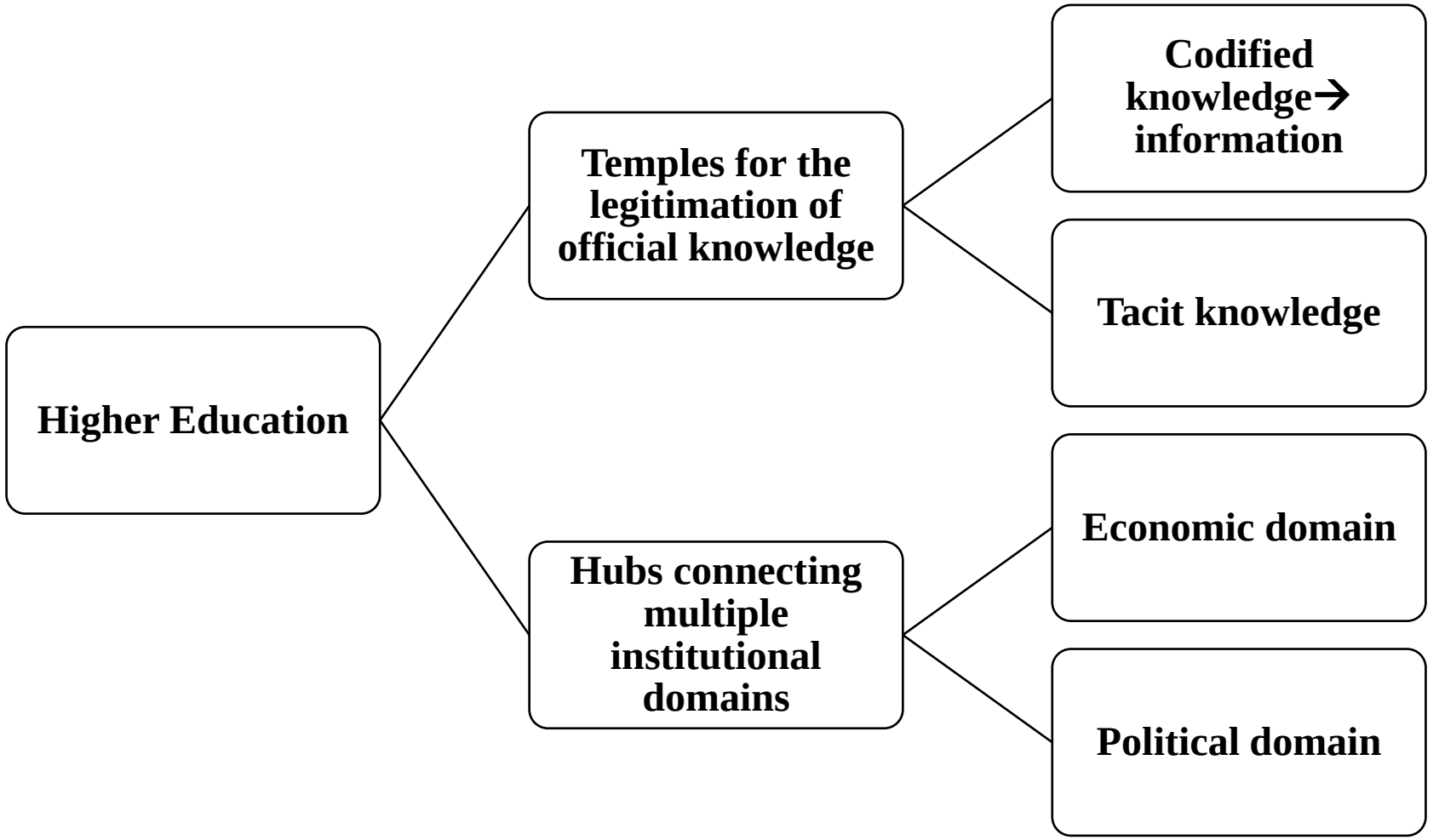


Function of higher education in society



Stevens, M. L., Armstrong, E. A., & Arum, R. (2008). Sieve, incubator, temple, hub: Empirical and theoretical advances in the sociology of higher education. Annu. Rev. Sociol, 34, 127-151.

Function of higher education in society

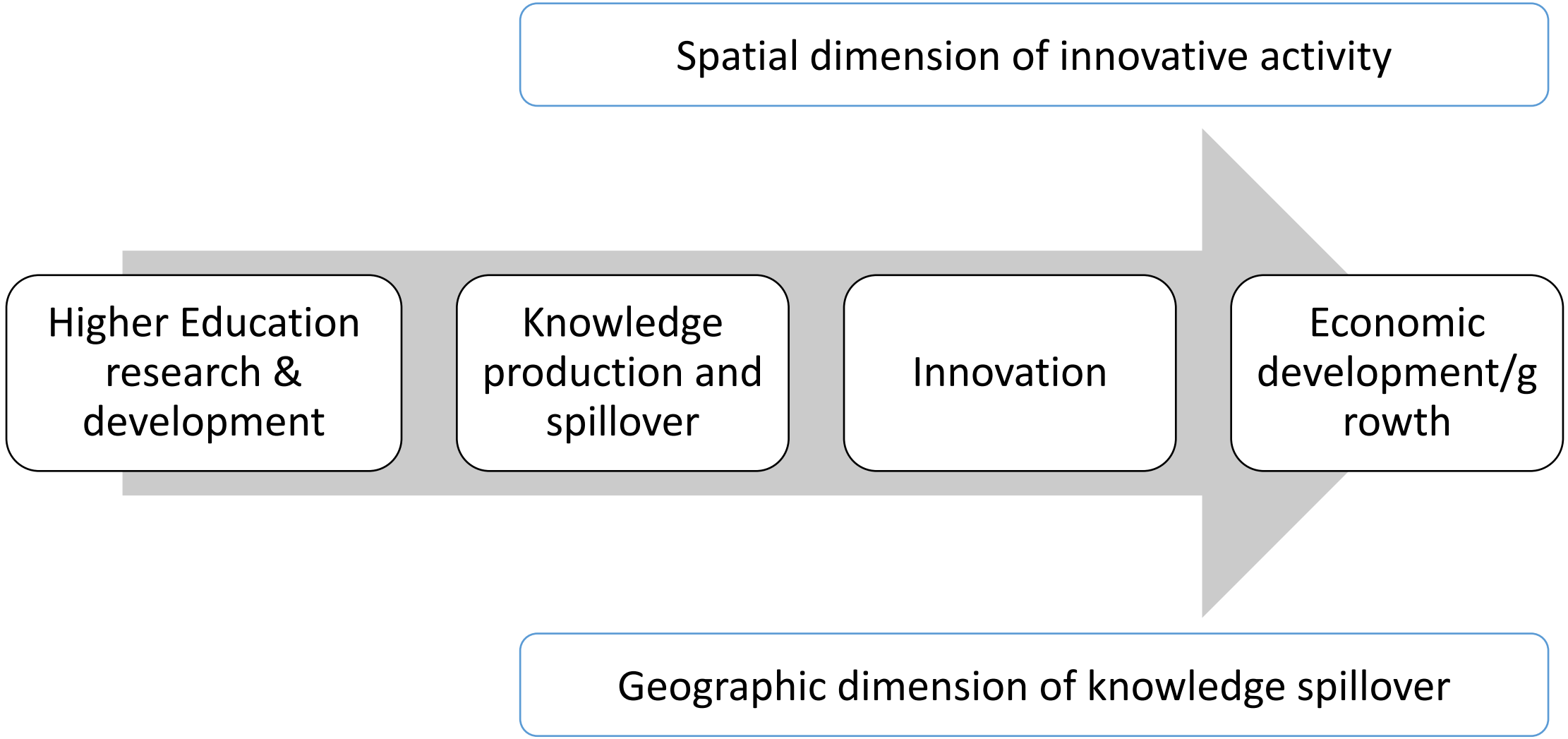


Knowledge production and knowledge spillover

Triple Helix of innovation

KNOWLEDGE SPILLOVER AND INNOVATION

Audretsch and Feldman (2004) Knowledge spillover and geography of innovation



Audretsch and Feldman (2004)

Technology change → Innovation

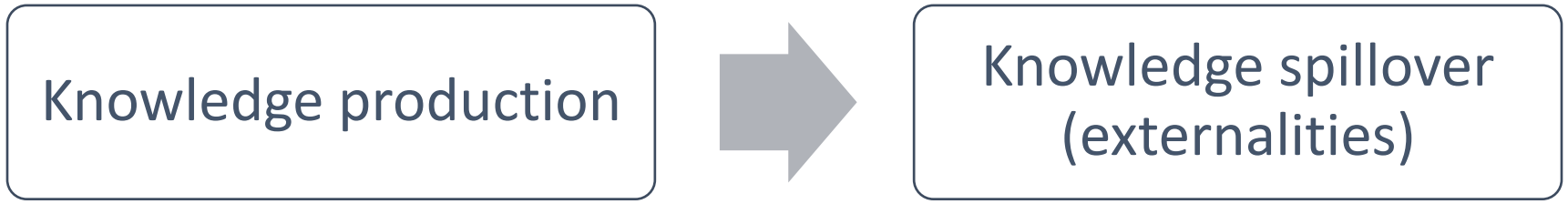
Knowledge production function

$$I_i = \alpha RD_i^{\beta} HK_i^{\gamma} \varepsilon_i \qquad (1)$$

where I stands for the degree of innovative activity, RD represents R&D inputs, and HK represents human capital inputs. The unit of observation for estimating the model of the knowledge production function, reflected by the subscript i, has been at the level of countries, industries and enterprises.

Innovation output is a function of innovative inputs

Audretsch and Feldman (2004)



Knowledge spillover

- Externalities associated with knowledge due to its non-exclusive and non-rival use (Arrow, 1962)

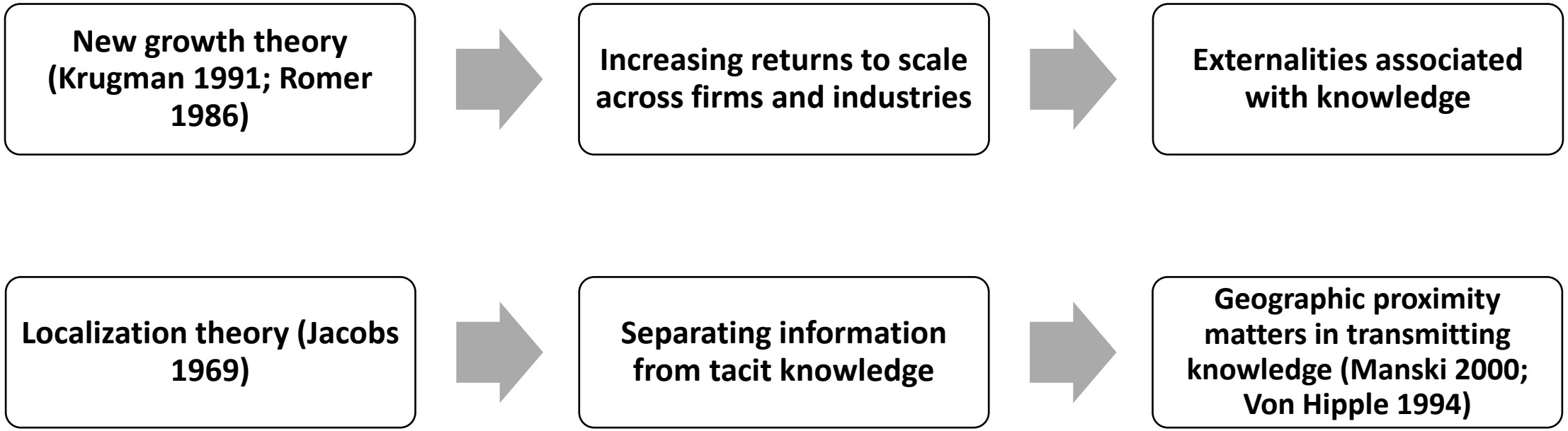
New model of knowledge production function

- Geographically bounded knowledge spillovers

Audretsch and Feldman (2004)

New model of knowledge production function

Geographically bounded knowledge spillovers



Audretsch and Feldman (2004)

Evidence of geographically bounded knowledge spillovers

Table 1: Innovative Activity in Cities

Consolidated Metropolitan Statistical Area	Innovations	Population (thousands)	Innovations per 100,000 Population
San Francisco - Oakland	477	5368	8.886
Boston – Lawrence	345	3972	8.686
New York - Northern New Jersey	735	17539	4.191
Philadelphia - Wilmington	205	5681	3.609
Dallas - Fort Worth	88	2931	3.002
Hartford	30	1014	2.959
Los Angeles - Anaheim	333	11498	2.896
Buffalo – Niagara	35	1243	2.816

Audretsch and Feldman (2004)

New model of knowledge production function

Jaffe (1989) estimated a model specified for both spatial and product dimensions

$$I_{si} = \alpha IRD^{\beta_1} * UR_{si}^{\beta_2} * (UR_{si} * GC_{si}^{\beta_3}) * \varepsilon_{si} \qquad (2)$$

where I is innovative output, IRD is private corporate expenditures on R&D, UR is the research expenditures undertaken at universities, and GC measures the geographic coincidence of university and corporate research. The unit of observation for estimation was at the spatial level, s, a state, and industry level, i. Estimation of equation (2) essentially shifted the knowledge production function from the unit of observation of a firm to that of a geographic unit. Implicitly contained within the knowledge production function model is the

Audretsch and Feldman (2004)

New model of knowledge production function

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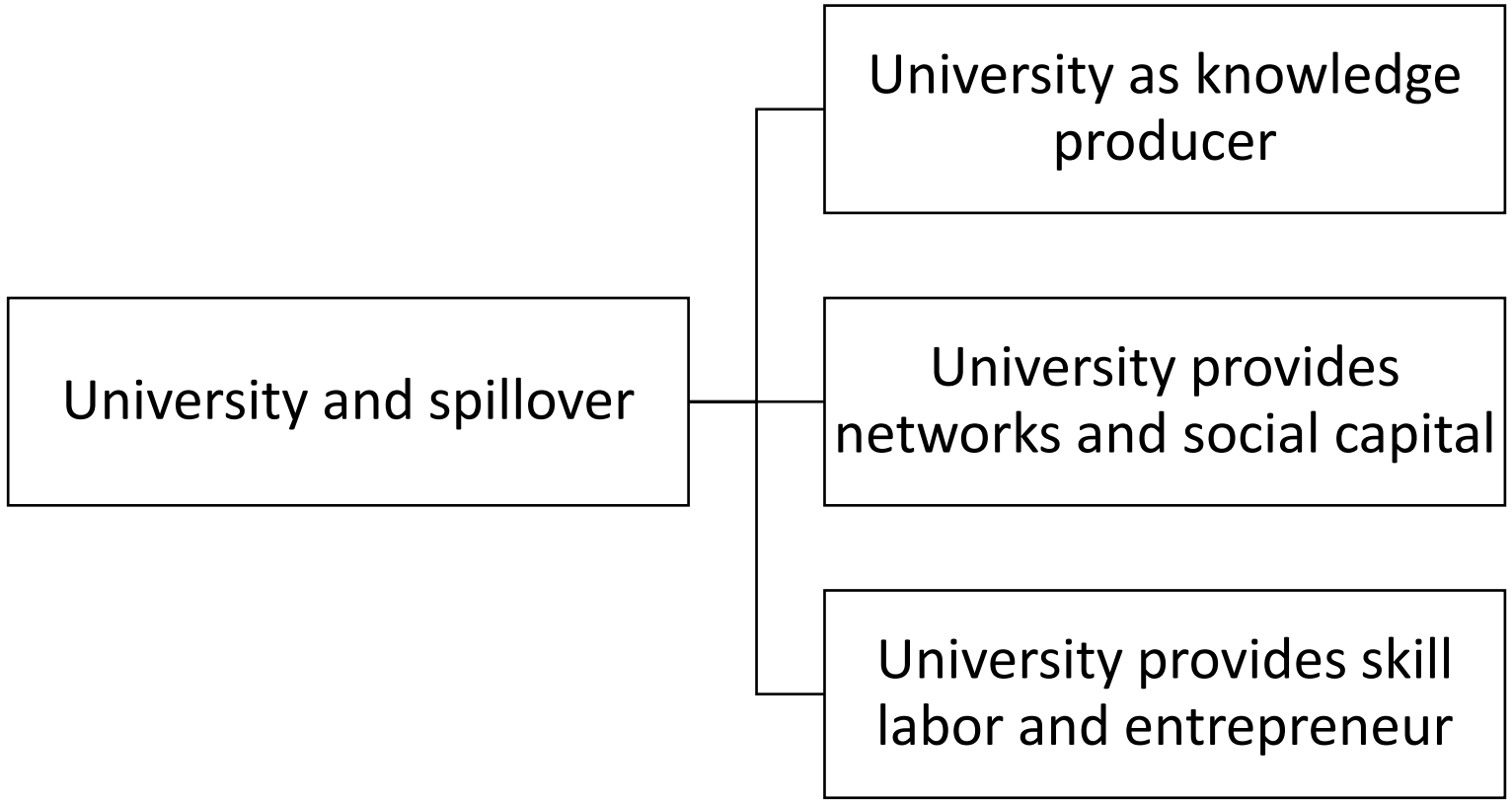
$$I_{si} = \alpha IRD^{\beta_1} * UR_{si}^{\beta_2} * (UR_{si} * GC_{si}^{\beta_3}) * \varepsilon_{si}$$

R&D expenditure made by private firms is important for in providing knowledge inputs to innovative activities in large firms

R&D expenditure made by universities is especially key for generating innovative activities in small firms

Audretsch and Feldman (2004)

Spillover mechanisms: university-industry-government interaction



Audretsch and Feldman (2004)

Spillover mechanisms: university-industry interaction

University as knowledge producer

University produces innovation-generating knowledge (Mansfield 1995,1998)

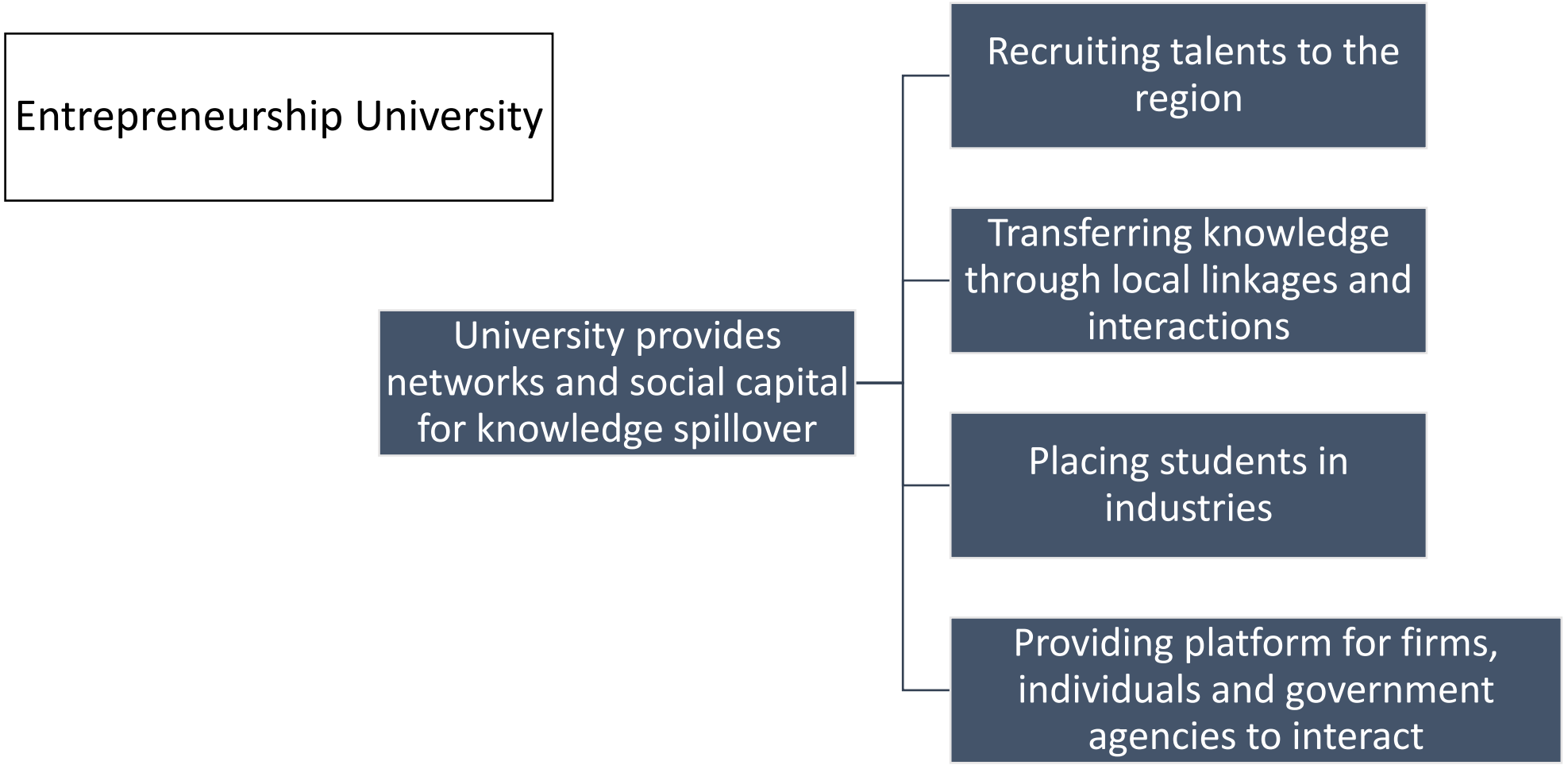
Firms acquire and benefit from external knowledge by cultivating relationship with university and partnering with academics (Cockburn and Henderson 1998)

Private enterprises generate commercial innovations who are connected to community of open science (Jaffe 1989; Audretsch and Feld man 1996)

Absorptive capacity (Agrawal 2000)

Audretsch and Feldman (2004)

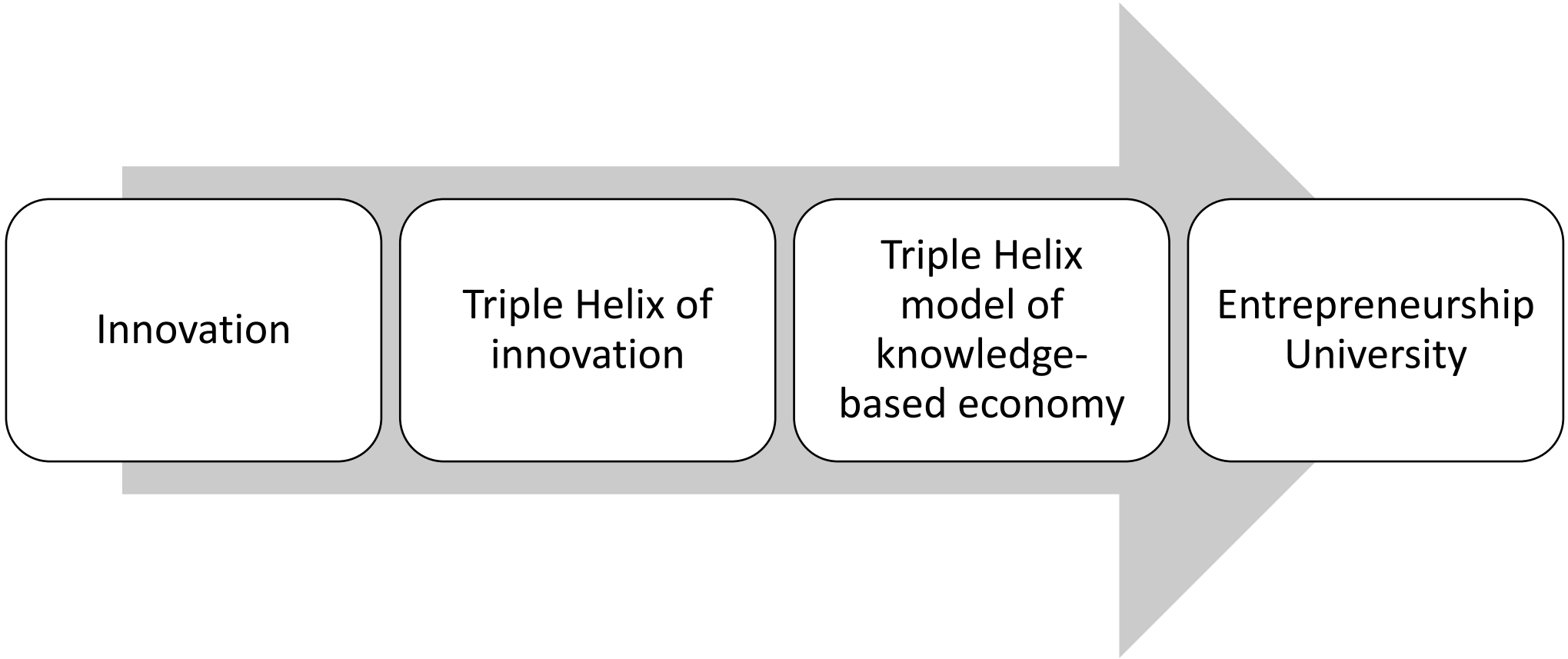
Spillover mechanisms: university-industry-government interaction



Higher Education and Innovation

TRIPLE HELIX MODEL OF INNOVATION

Etzkowitz and Leydesdorff (2005,2010)



Etzkowitz and Leydesdorff (2005,2010)

Mission of university

Humboldt changed all that by making research a vital complement of teaching, by emphasizing science, by urging traffic across disciplinary boundaries, and by attempting to make the university contribute more directly to economy and society (Ruegg 2004)

The two additional roles universities acquired post-Humboldt—**that of conducting basic research to advance knowledge and that of contributing to the development and assimilation of technology for civilian or military uses—have** been adopted partially and unevenly over time and among countries by a few elite universities

Direct contribution to industry as “third mission” of university → Role of university in economic development

Etzkowitz and Leydesdorff (2005,2010)

From linear innovation and non-linear innovation

The linear model of innovation in which basic research invents and industry applies with a one-directional arrow between them is replaced with an interactive and nonlinear model (Godin, 2006b; Rosenberg, 1994)

The linear model either expressed in terms of ‘‘market pull’’ or ‘‘technology push’’ was insufficient to induce transfer of knowledge and technology

Triple Helix Model as an alternative

Etzkowitz and Leydesdorff (2005,2010)

Triple Helix configuration

Statist Model

The nation state encompasses academia and industry and directs the relations between them

This model could be found in the former Soviet Union and in Eastern European countries under ‘‘existing socialism’’

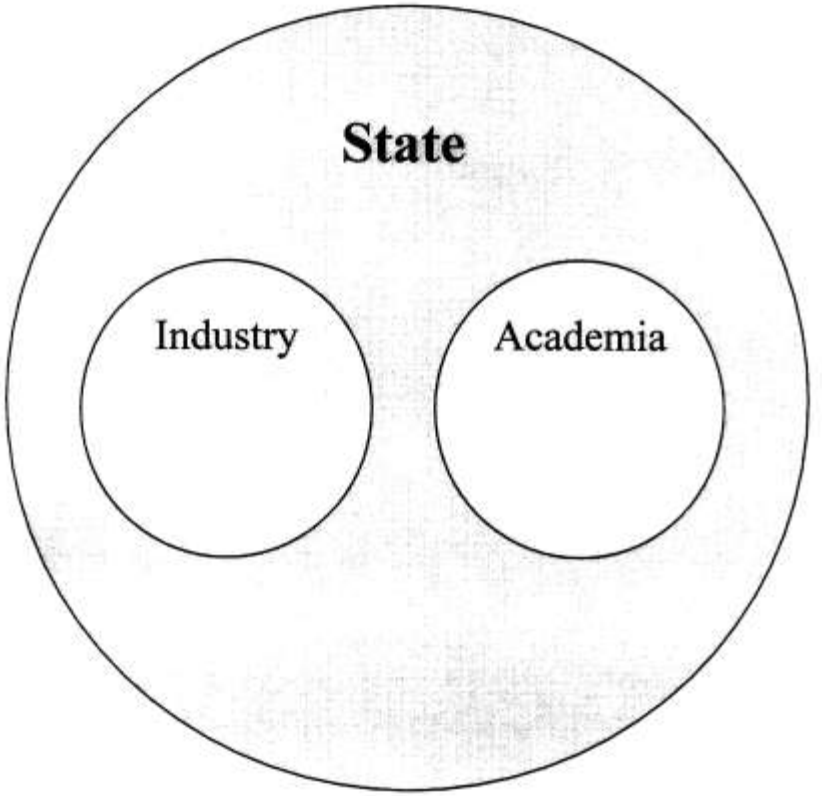


Fig. 1. An etatistic model of university–industry–government relations.

Etzkowitz and Leydesdorff (2005,2010)

Triple Helix configuration

Laissez-faire Model

Separate institutional spheres with strong borders dividing them and highly circumscribed relations among the spheres

Exemplified in Sweden by the noted *Research 2000 Report* and in the US

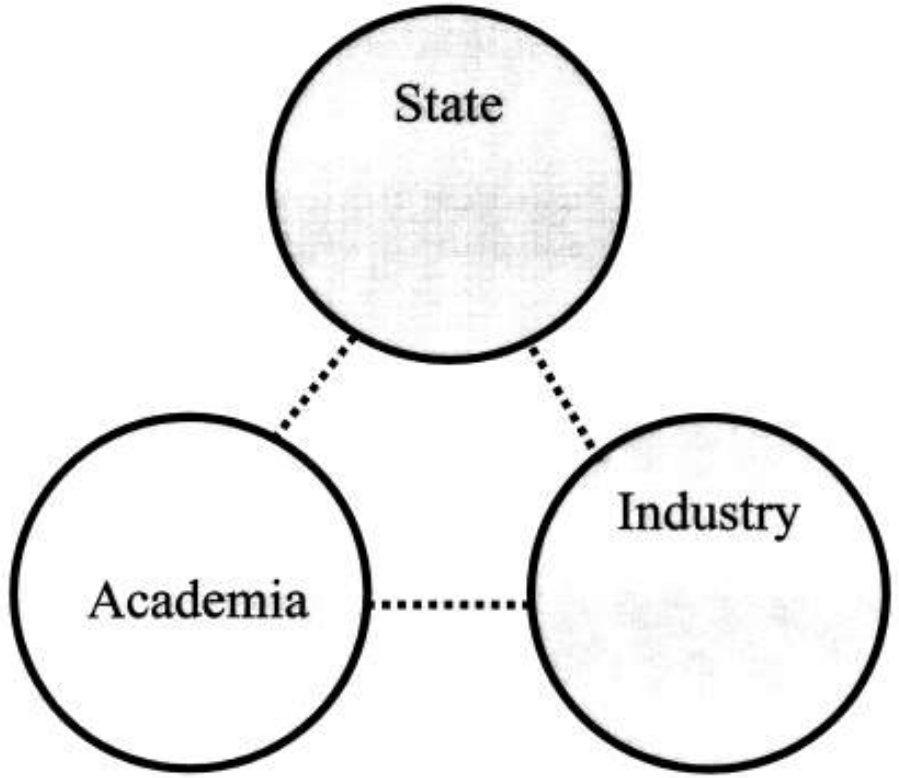


Fig. 2. A ''laissez-faire'' model of university–industry–government relations.

Etzkowitz and Leydesdorff (2005,2010)

Triple Helix configuration

Overlapped Model

Generating a knowledge infrastructure in terms of overlapping institutional spheres, with each taking the role of the other and with hybrid organizations emerging at the interfaces

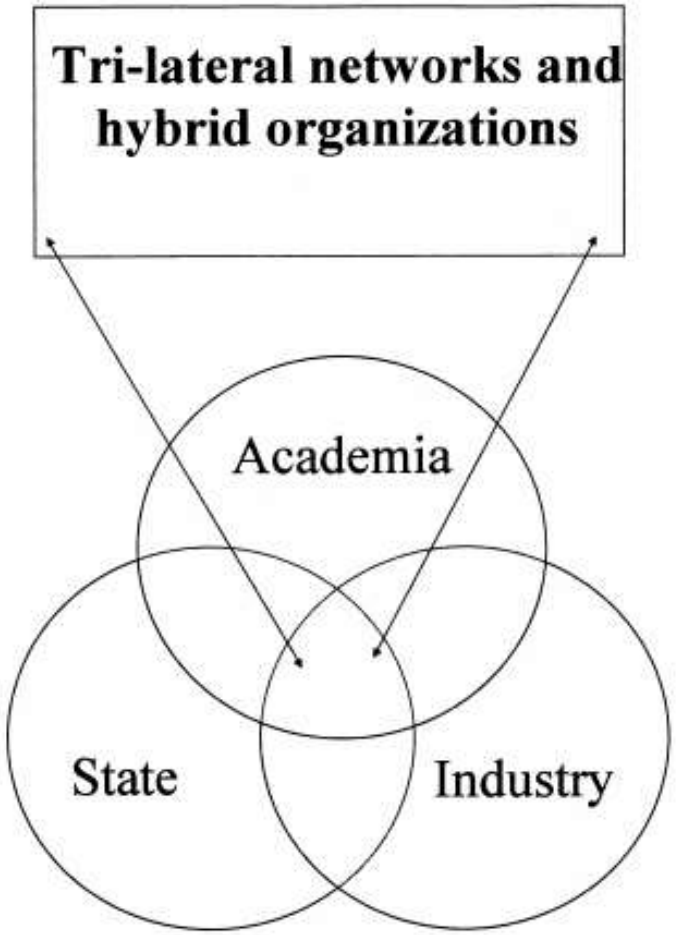


Fig. 3. The Triple Helix Model of University–Industry–Government Relations.

Etzkowitz and Leydesdorff (2005,2010)

Triple Helix configuration

Adopting Overlapped Model

The common objective is to realize an innovative environment consisting of university spin-off firms, tri-lateral initiatives for knowledge-based economic development, and strategic alliances among firms (large and small, operating in different areas, and with different levels of technology), government laboratories, and academic research groups

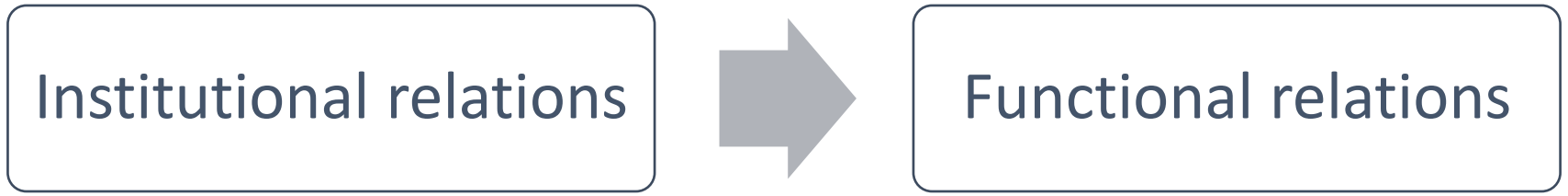
These arrangements are often encouraged, but not controlled, by government, whether through new ‘‘rules of the game,’’ direct or indirect financial assistance, or through the Bayh–Dole Act in the USA

Etzkowitz and Leydesdorff (2005,2010)

Triple Helix interactions

The Triple Helix model of the knowledge-based economy defines the main institutions as university, industry, and government (Etzkowitz & Leydesdorff, 1995)

These institutional carriers of an innovation system can be expected to entertain a dually layered network: One layer of **institutional relations** in which they constrain each other's behavior and another layer of **functional relations** in which they shape each other's expectations



Etzkowitz and Leydesdorff (2005,2010)

Institutional relations → Functional relations

The Interaction Between Functional and Institutional Differentiation (Since Approximately 1870)

	Functions	
Institutions	*Science*	*Economy*
Public	Academia; University	Patent legislation; Science, technology, and innovation policies
Private	Industrial R&D labs; entrepreneurial universities	Trade and Industry

Etzkowitz and Leydesdorff (2005,2010)

Triple Helix interactions

The knowledge base of an economy can be considered as a specific configuration in the structure of expectations, which feeds back as a transformation mechanism on the institutional arrangements

Three subdynamics are reproduced as functions of a knowledge-based economy

- Wealth generation in the economy
- Novelty generation by organized science and technology
- Governance of the interactions among these two subdynamics by policy making in the public sphere and management in the private sphere.

Etzkowitz and Leydesdorff (2005,2010)

Triple Helix interactions

- Economic and political mechanisms no longer control, but function as selective feedback mechanisms that enable and constrain the development of scientific and technological knowledge
- Development of scientific and technological knowledge has become a structural condition and a limiting factor on further socio-economic development

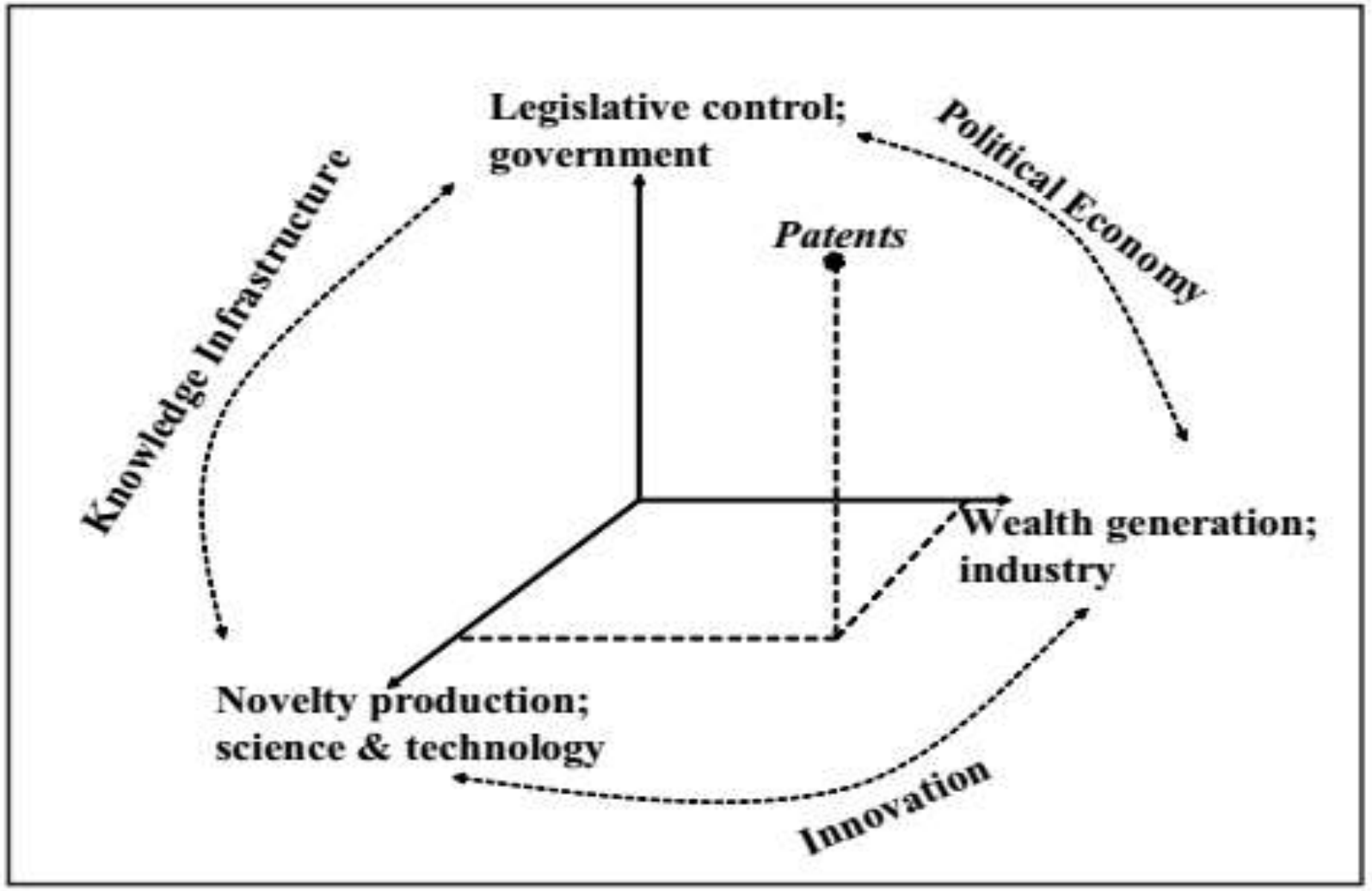


Figure 9.1 Patents as events in the three-dimensional space of triple helix interactions

Etzkowitz and Leydesdorff (2005,2010)

Dimensions of innovation system

- 3 dimension of innovation system: geographically positioned units of analysis (e.g., firms, institutions), economic exchange relations, and novelty production

- (1) the geography, which organizes the positions of agents and their aggregates; (2) the economy, which organizes their exchange relations; and (3) the knowledge content, which emerges with reference to either of these dimensions (Archer, 1995)

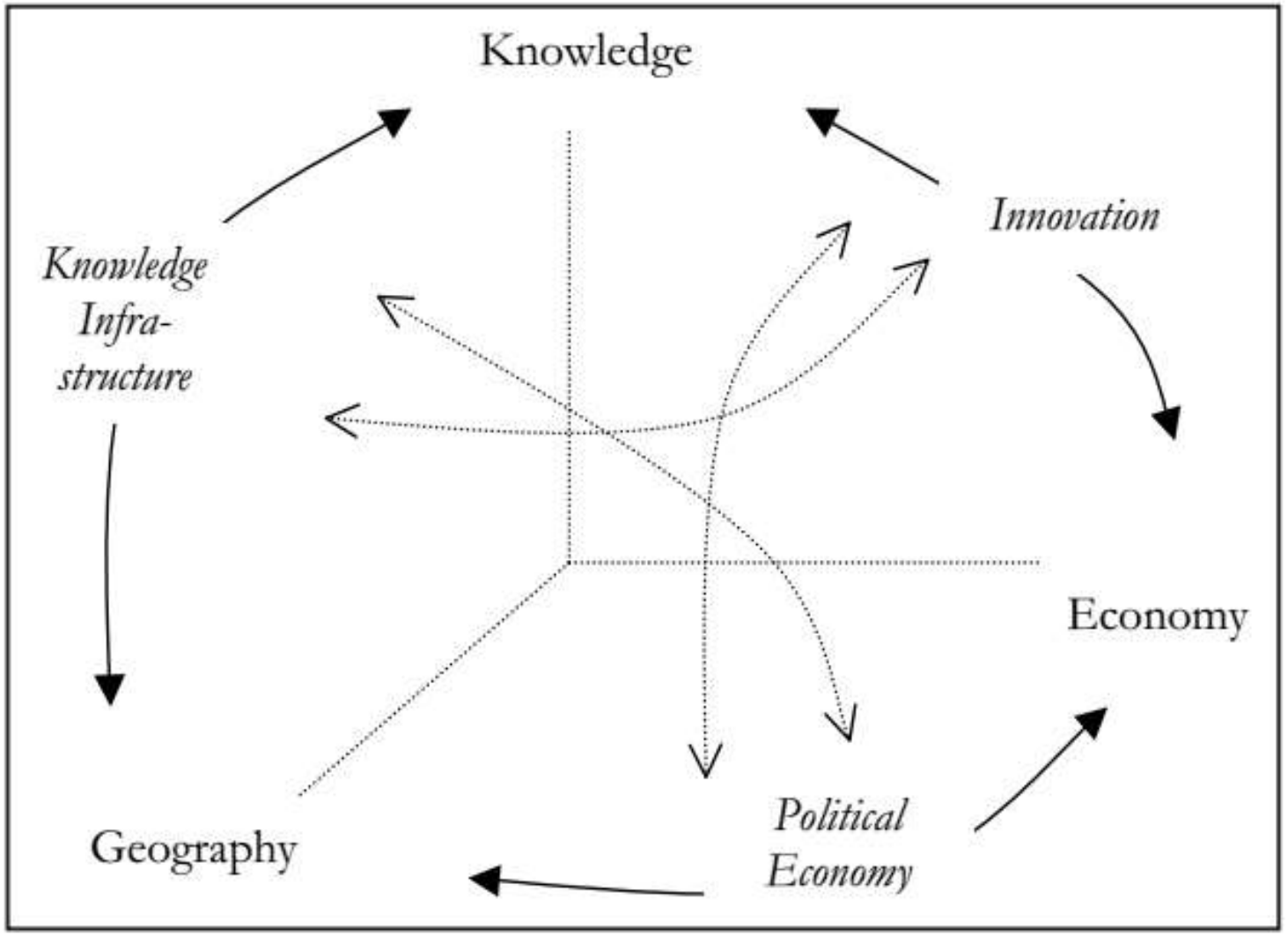


Figure 9.3 Three dimensions of the social system with their interaction terms

Etzkowitz and Leydesdorff (2005,2010)

Triple Helix of coordination mechanism

- A configuration with three possible degrees of freedom—markets, governance, and knowledge production—can be modeled in terms of a Triple Helix of university-industry-government relations (Etzkowitz & Leydesdorff, 2000)
- The interfaces between institutions and functions can be expected to co-evolve

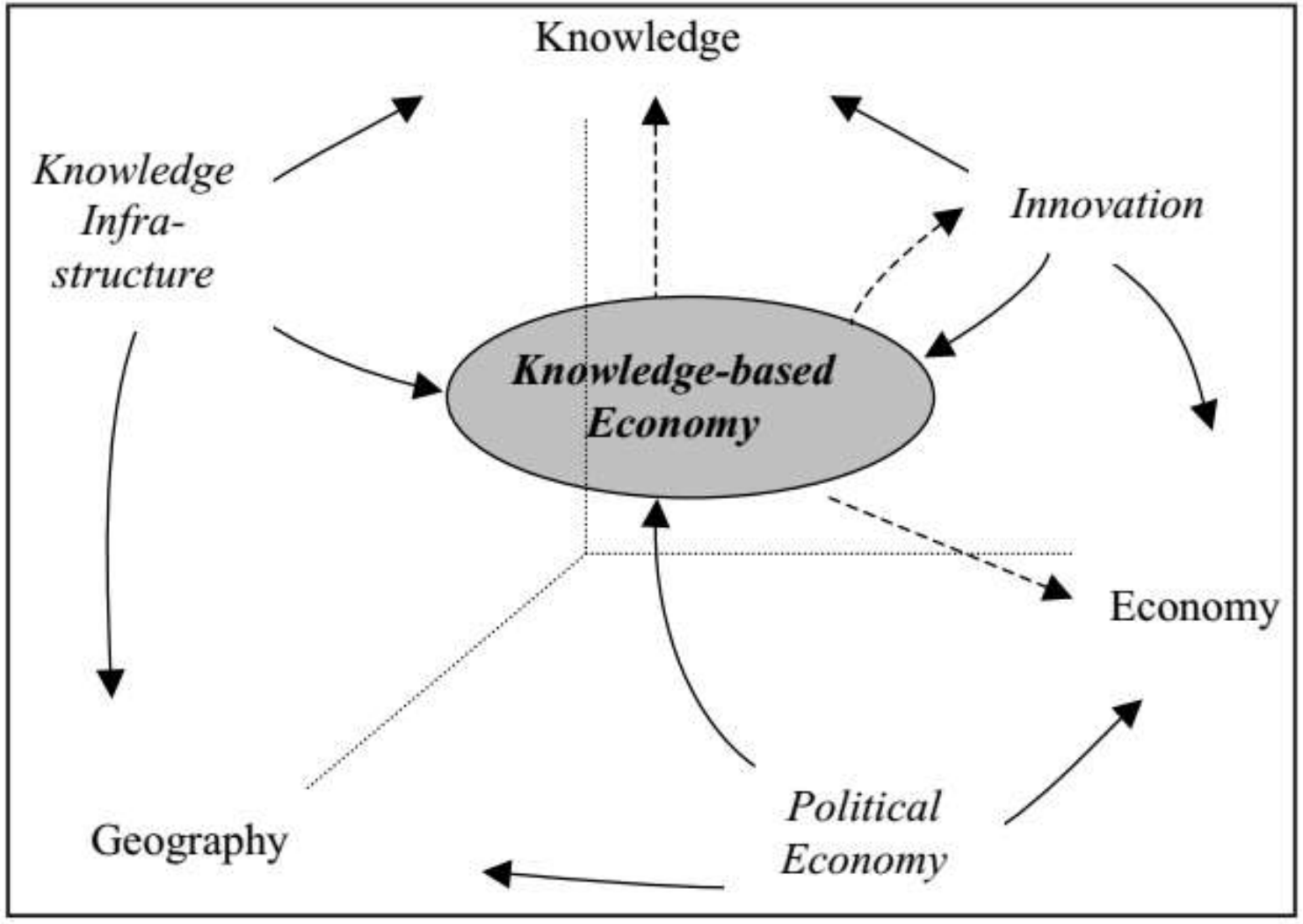


Figure 9.4 The first-order interactions generate a knowledge-based economy as a next-order system.

Etzkowitz and Leydesdorff (2005,2010)

Micro-foundation of the Triple Helix model

Each agent is positioned differently in terms of preferences → Agents interact → the arrangement of positions (nodes) and relations (links) contains information → Agents at local nodes recognize the expected information → The recognitions provide meanings to be communicated → Generate knowledge base → knowledge can be processed as discursive knowledge in network of exchange relations

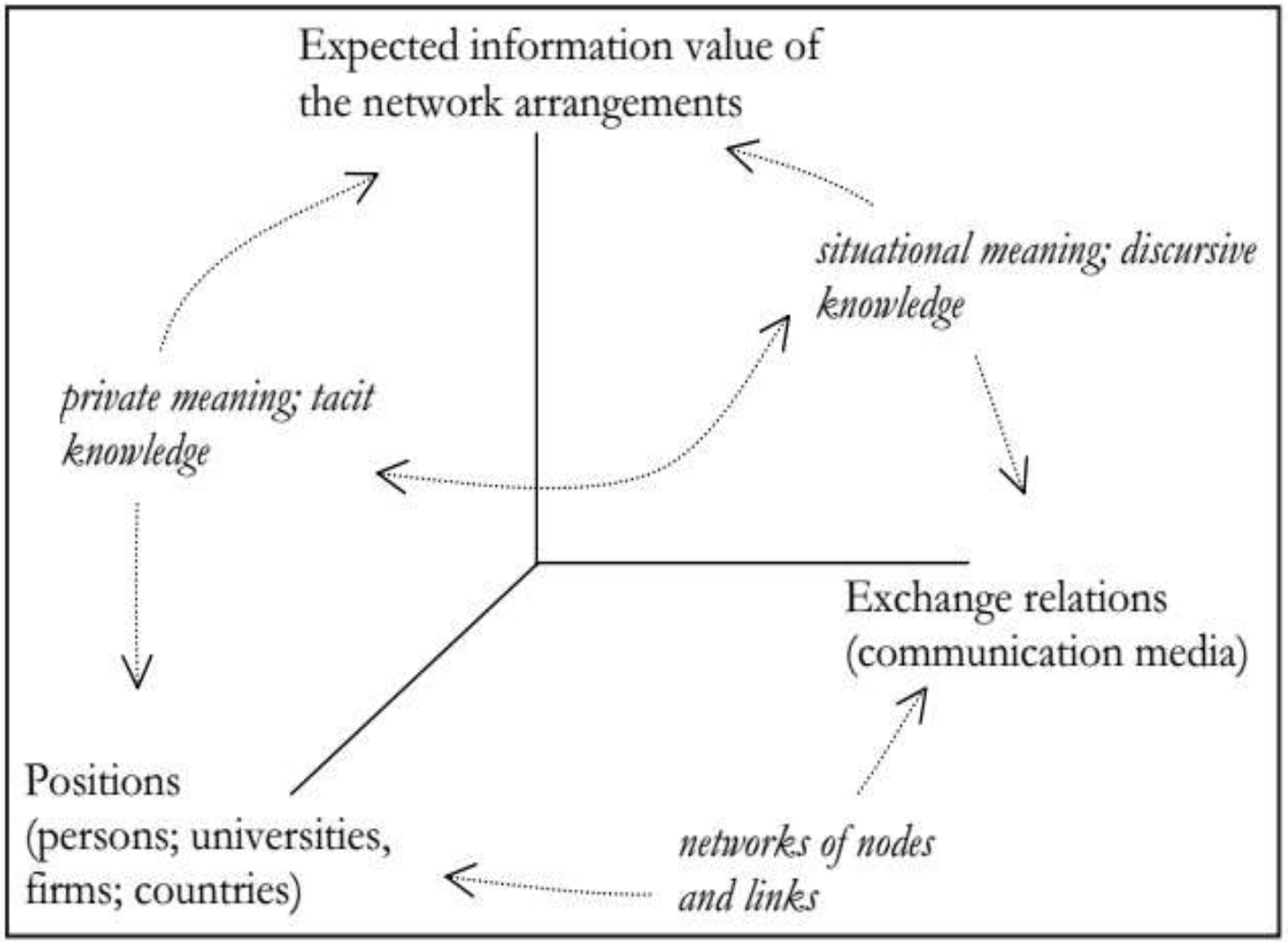
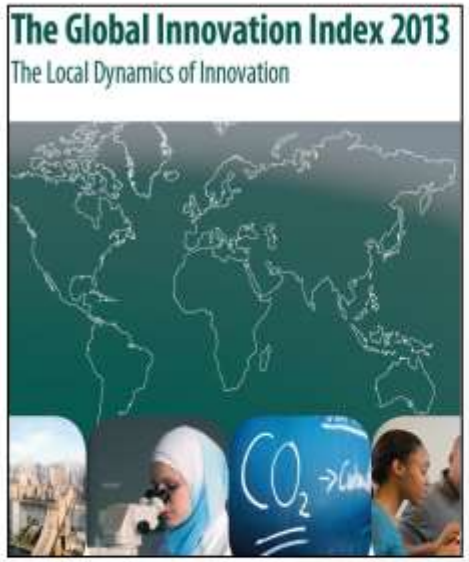


Figure 9.5 Micro-foundation of the triple helix model of innovations

MEASURED UNIVERSITY-INDUSTRY-GOVERNMENT LINKAGE

How to measure university-industry connectivity ?

How to measure university-industry connectivity within countries worldwide … and within national higher education systems ?



Robert Tijssen (2013) Measuring University-Industry Research Connectivity, *U21 Symposium*

How to measure university-industry connectivity ?

5.2.1 University/industry research collaboration

Average answer to the survey question: To what extent do business and universities collaborate on research and development (R&D) in your country? (1 = Do not collaborate at all; 7 = Collaborate extensively) | 2012

	U/I RC score
Switzerland	5.93
United Kingdom	5.75
United States	5.63
Finland	5.60
Singapore	5.59
Belgium	5.52
Sweden	5.42
Israel	5.39
Qatar	5.39
Netherlands	5.30

GII/GCR vantage point

Survey-based information

Business sector perspective; recent past

General notions and opinions of corporate CEOs or R&D managers

Data collection protocols and sample characteristics of the survey data are unknown

Data quality is questionable ?

PPC and UIC

Public-Private Co-publications (PPCs)

Research publications listing a public sector organization

and a private sector organization

within the author affiliate address information

University-Industry Co-publications (UICs)

Research publications listing a university (either public or private)

and a for-profit business company

within the author affiliate address information

PPC data – countries by location of the for-profit company

Indicator: Country-level PPC counts normalized by millions inhabitants ('PPC intensity' score)

Published in EC annual series of *Innovation Union Scoreboards*

UIC data – countries by location of university

Indicator: Country-level UIC counts normalized by total university publication output (% UICs; 'UIC intensity' score)

Unpublished data

UIC performance of national higher education systems

'UIC – Overall' indicator

Top 10 ranking countries

	% UIC Overall
Iceland	11.2
Sweden	8.0
Denmark	7.7
Netherlands	7.2
Austria	6.8
Japan	6.4
Finland	6.4
Korea	6.2
Norway	6.1
Estonia	5.2
WORLD	**4.1**

Source: CWTS, Leiden University (data source: Thomson Reuters Web of Science)

'UIC – Domestic Cooperation'

Top 10 ranking countries

	% UIC Domestic	% of all UICs
Iceland	6.9	61
Japan	5.7	89
Korea	5.1	83
United States	4.2	84
Denmark	4.0	52
Sweden	3.7	46
Slovenia	3.3	73
Finland	3.3	51
Netherlands	3.2	44
Norway	3.2	52
WORLD	**2.5**	**62**

Source: CWTS, Leiden University (data source: Thomson Reuters Web of Science)

UIC performance of individual universities

UIRC Scoreboard on CWTS website

UIC indicator in Leiden Ranking 2013

UIC indicator in U-Multirank 2014

http://www.socialsciences.leiden.edu/cwts/research/uirc-scoreboard-2013.html

UIRC 2013 Profile - Overall

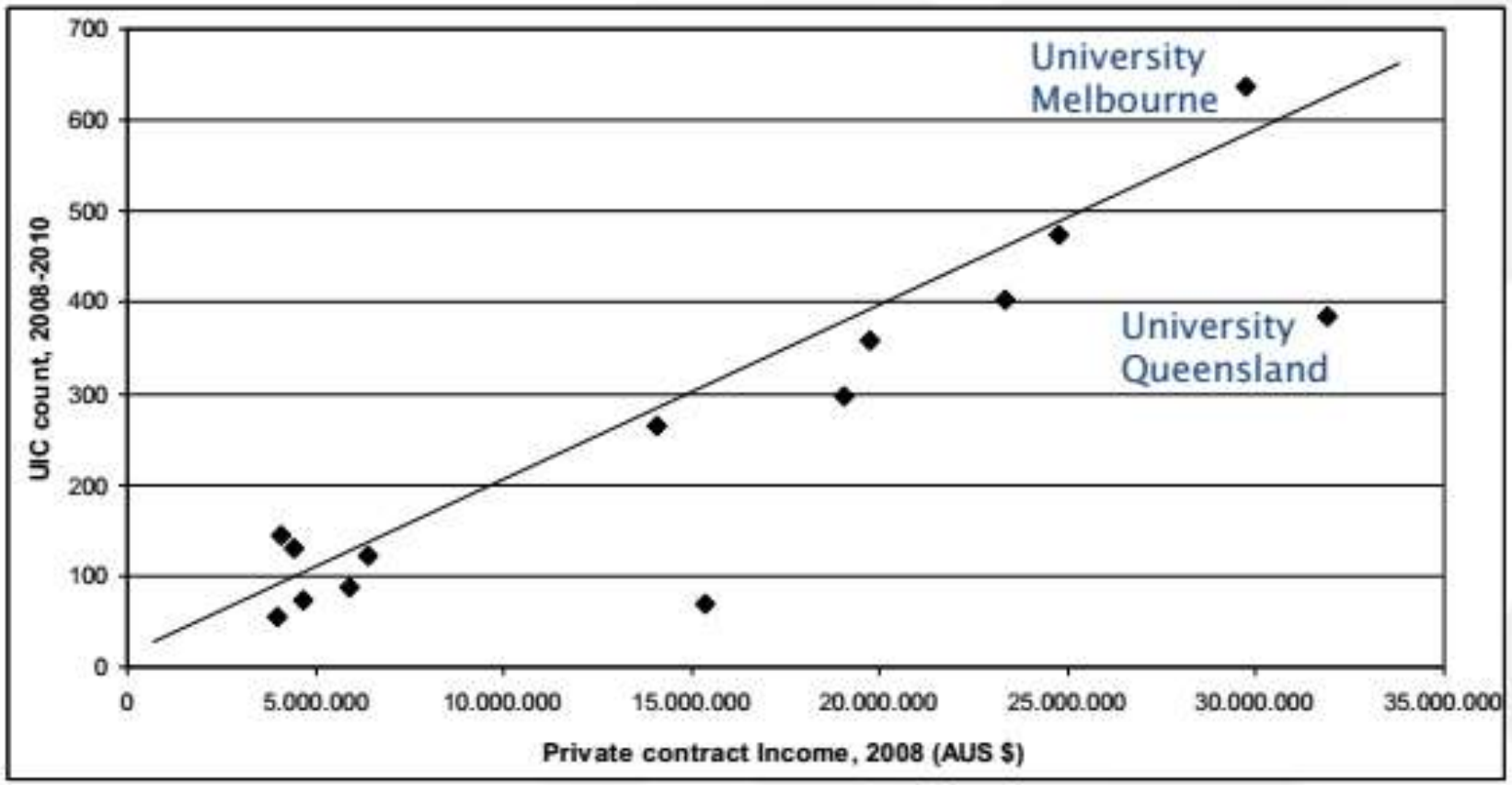
Fields of science	University X			World average	
	Output	% UIC	% Domestic	% UIC	% Domestic
All fields	17 321	4.8	30	5.9	44
Biomedical and health sci.	5 642	4.9	18	6.2	40
Life sci. and earth sci.	1 439	4.2	44	6.1	45
Math. and computer sci.	2 335	6.4	22	6.4	51
Natural sci. and eng.	6 542	5.1	43	6.3	46
Social sci. and humanities	1 363	0.9	4	1.8	49

CWTS data sources: UIRC 2013 and Leiden Ranking 2013 (Web of Science database; publication years: 2008-2011)

UIC output and research income: Australian Universities

Absolute measures

Total UIC count versus private contract income

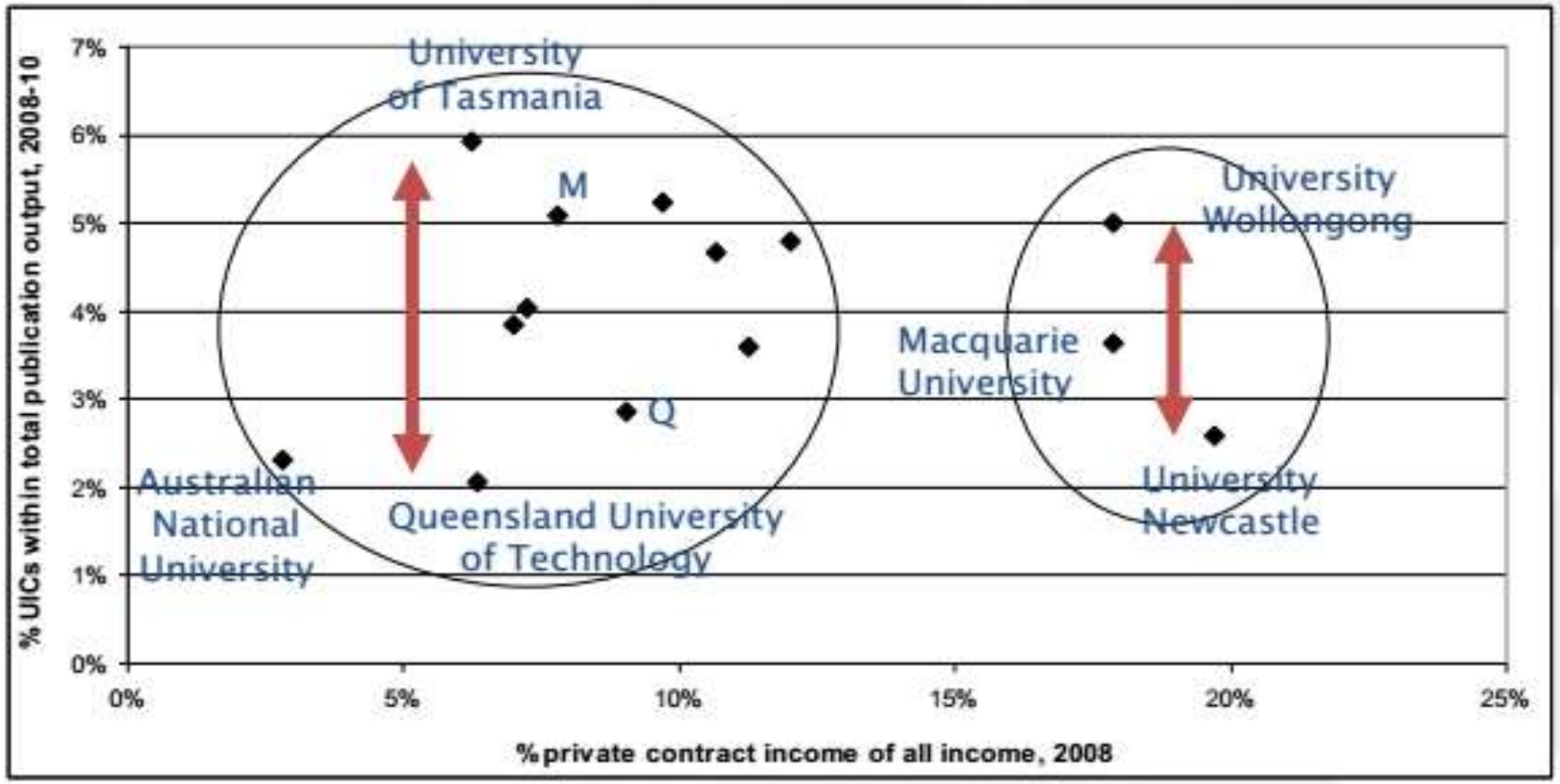


Source: CWTS, Leiden University; Data sources: Thomson Reuters Web of Science; Higher Education Research Data Collection (Australian Government statistics)

UIC output and research income: Australian Universities

Relative measures

% UICs versus % contract income



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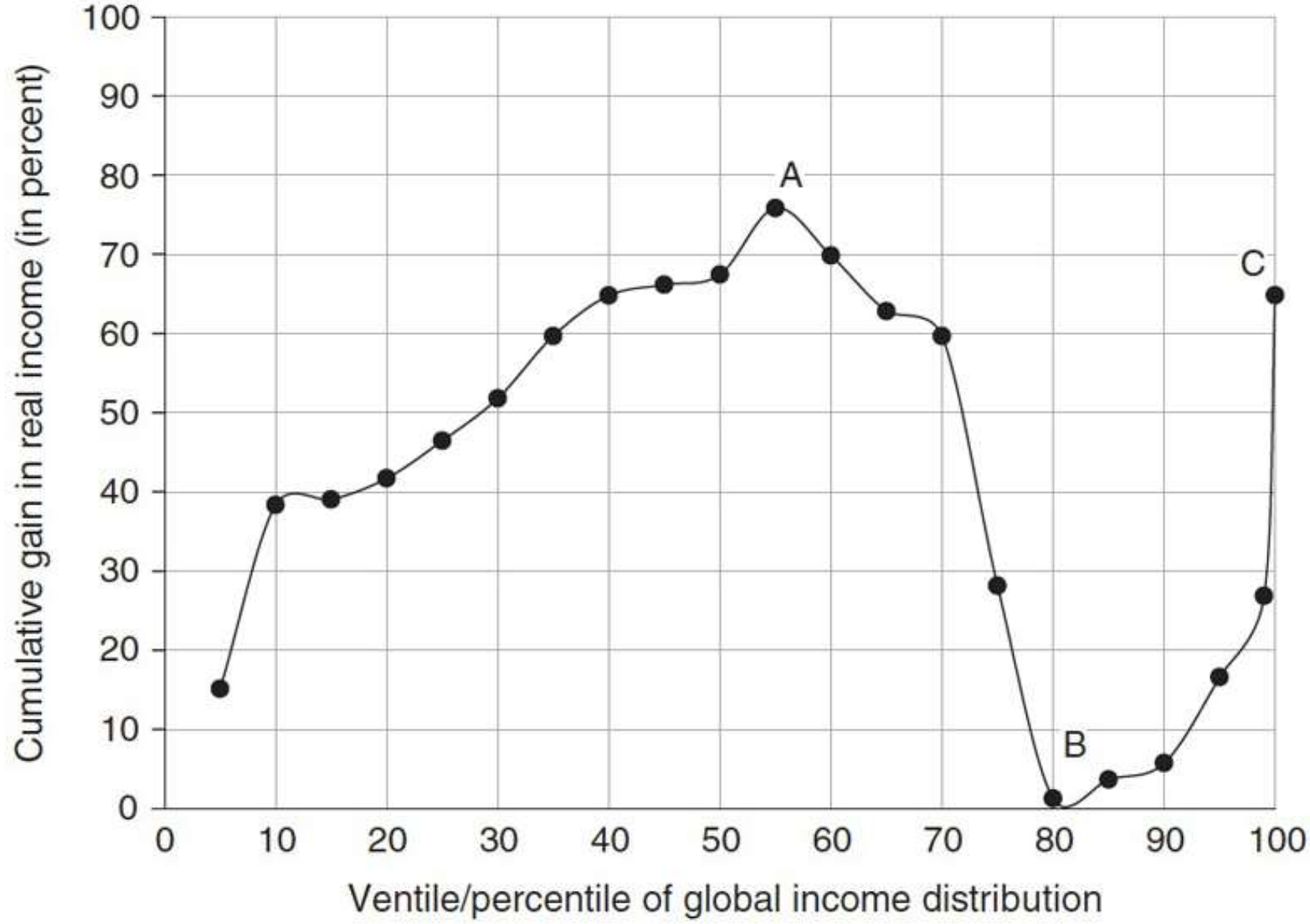

RELATIVE GAIN IN REAL PER CAPITA INCOME
BY GLOBAL INCOME LEVEL, 1988–2008

Thanks for your attention!

Poyang@pku.edu.cn

Global Entrepreneurial University Metrics

Cai and Liu (2014) Chinese regional innovation system

Tian and Liu (2018)