Varieties of the NIS & RIS (National/Regional Innovation Systems) around the world:

Measurement by Patent data and Policy implications

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Variety of Innovation systems (IS):
A Schumpeterian Concept

National Innovation Systems = NIS
Sectoral = Sectoral SI (SSI)
Regional = Regional IS (RIS)
firm = Corporate IS (CIS)
Individual /Inventor (IIS?)

Lundvall (1992):

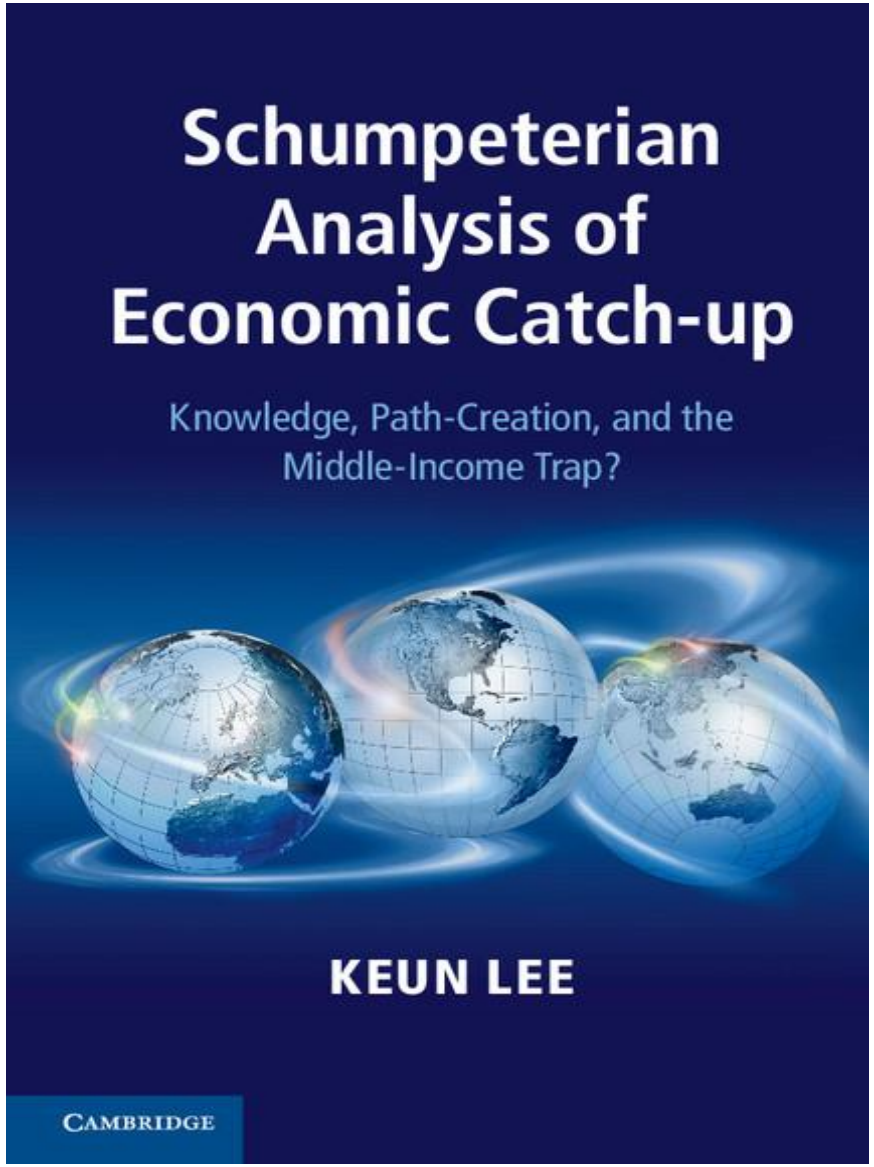
NIS (national Innovation system) = elements and relationships

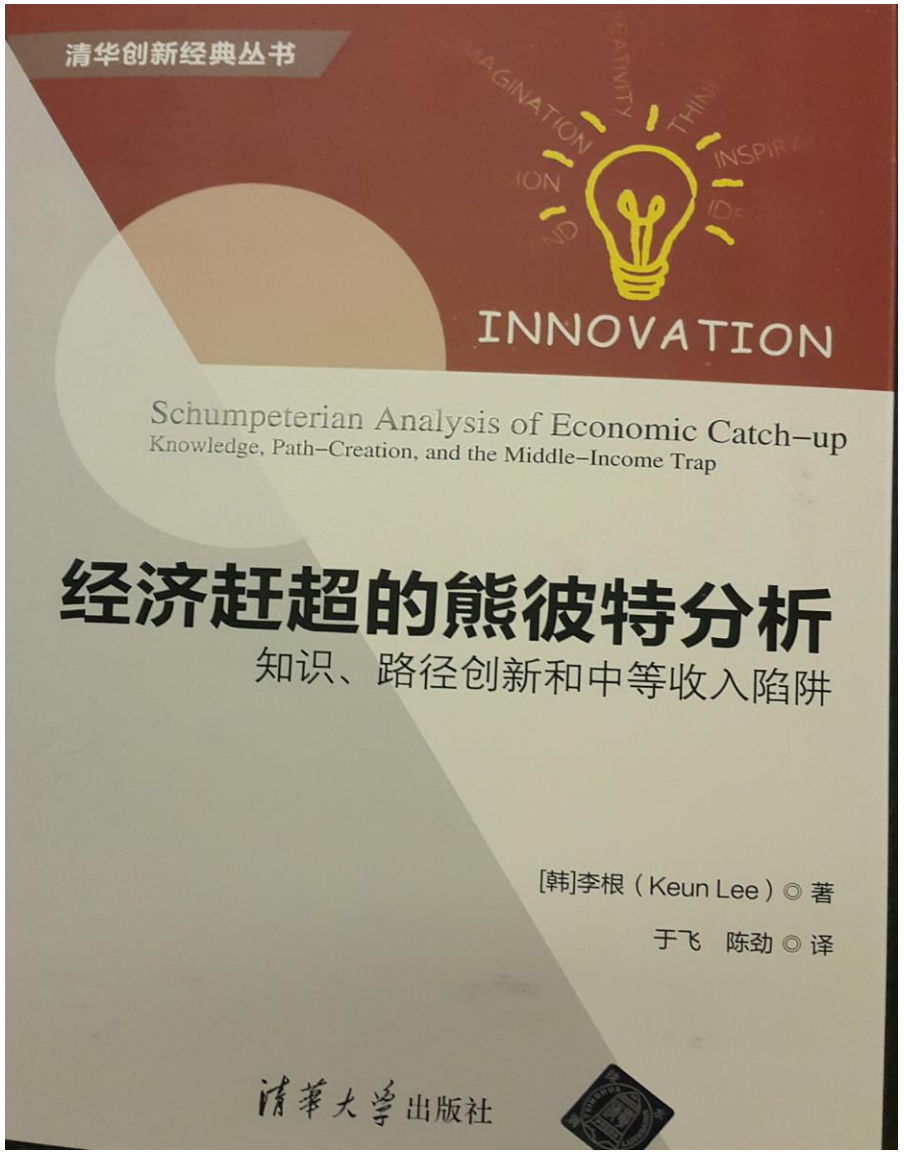
1) which interact in the production, diffusion and use of knowledge
2) rooted inside the borders of a nation state.

-> Differences in NIS determines competitiveness of nations, sectors and firms.
=> *System failure cf) market failure*

Innovation systems at 3 Levels: country; Sector; firm

=> 2014 Schumpeter Prize





5 Key Variables
to measure the NIS and RIS

Intra-national creation and diffusion of Knowledge (vs. reliance on foreign sources)
Balanced vs. Concentration of knowledge creation (by assignees)
Technological specialization 1 (short vs. long cycle technologies)
Knowledge Combination (by citing and combining widely) (formerly called originality of technologies; Convergence of knowledge)
Technological Diversification (Wide vs. Deep in patent portfolio)

NIS (national Innovation systems)

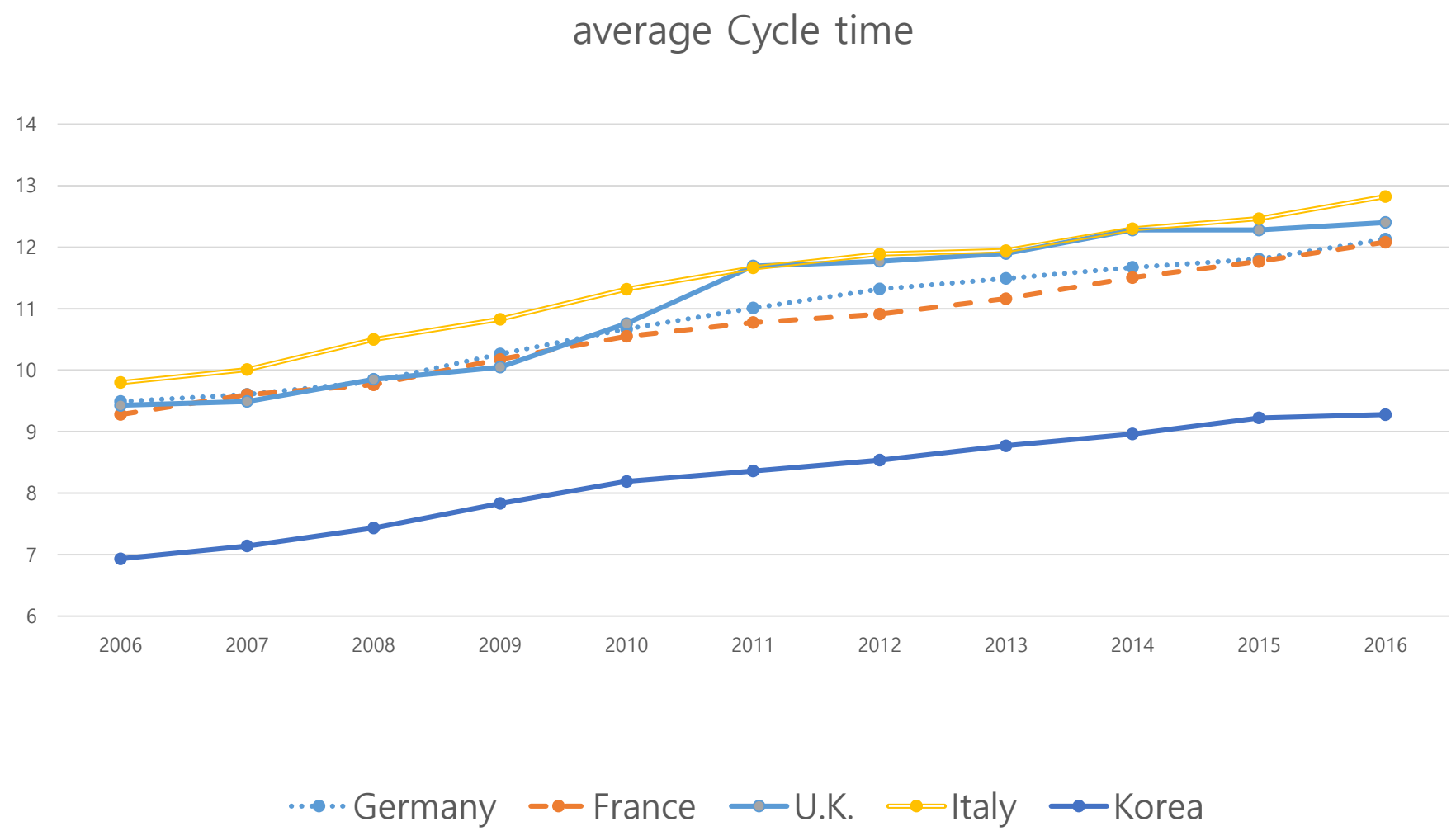
in

Italy, Germany, France and UK;
Compared with Korea

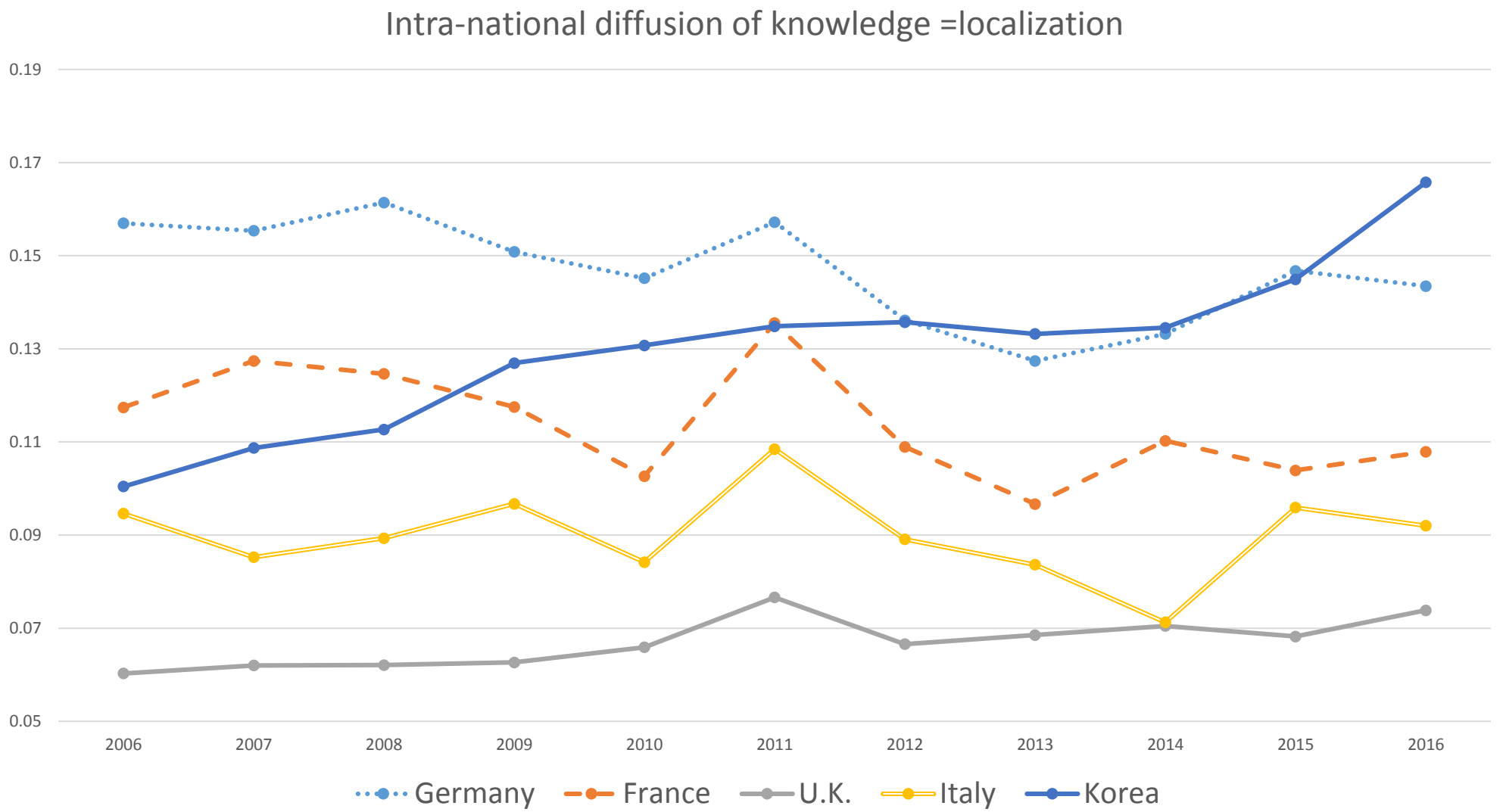
Data

- **USPTO Patent Grant Red Book (Full Text, 1976~2017, http://patents.reedtech.com/pgrbft.php)**
  - Information in the database:
    - patent number, series code and application number, type of patent, filing date, title, issue date, inventor information, assignee name at time of issue, foreign priority information, related US patent documents, classification information, US and foreign references, attorney, agent or firm/legal representative
- **Data cleaning:** using NBER DB: 1963-1999, 1976-2006 / Lai et al.(2011) / Kogan et al.(2015)

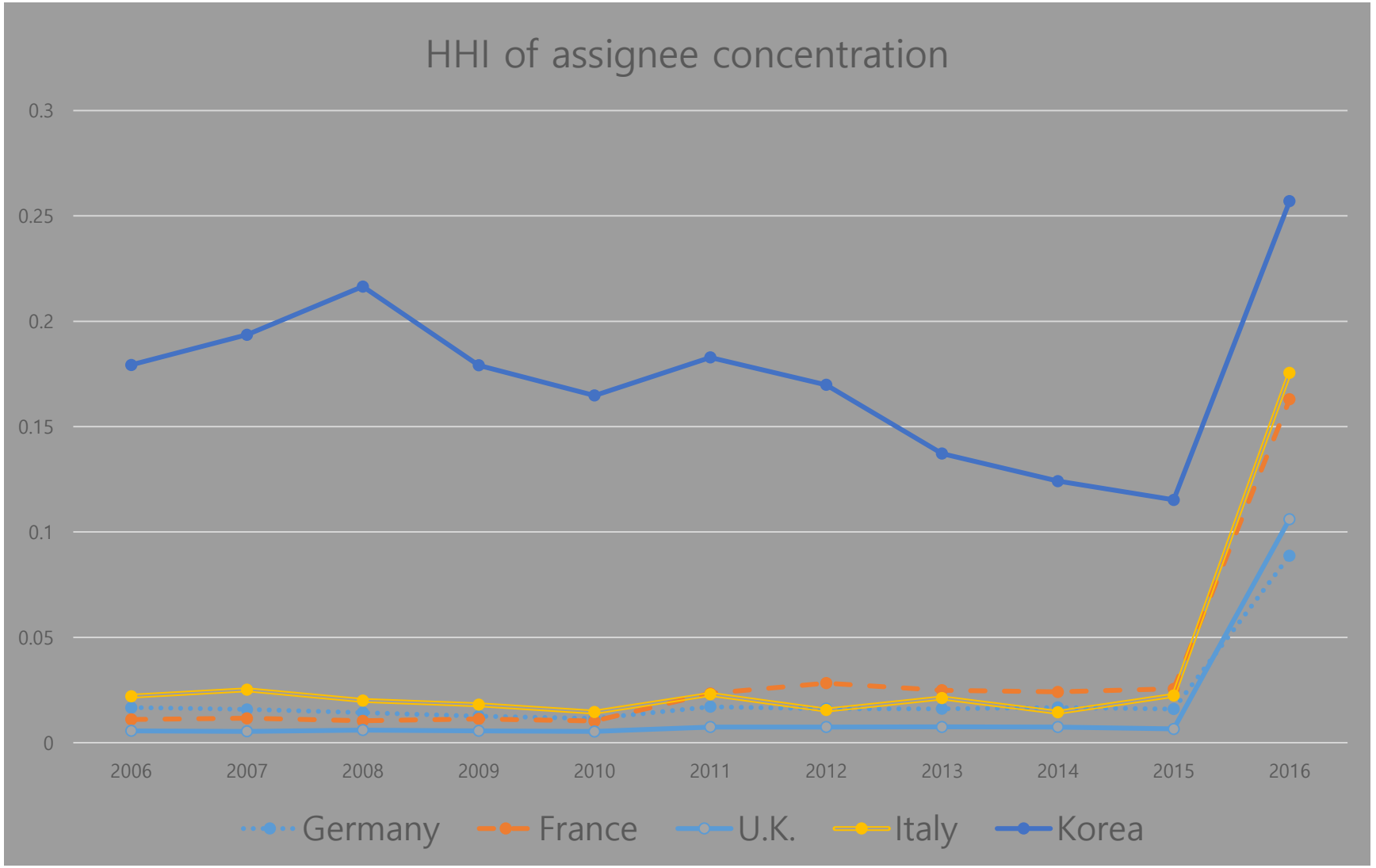
Italy = longest Cycle time (machineries) = good for profitability
Korea = shortest cycle time = vehicle for late entry and catch-up



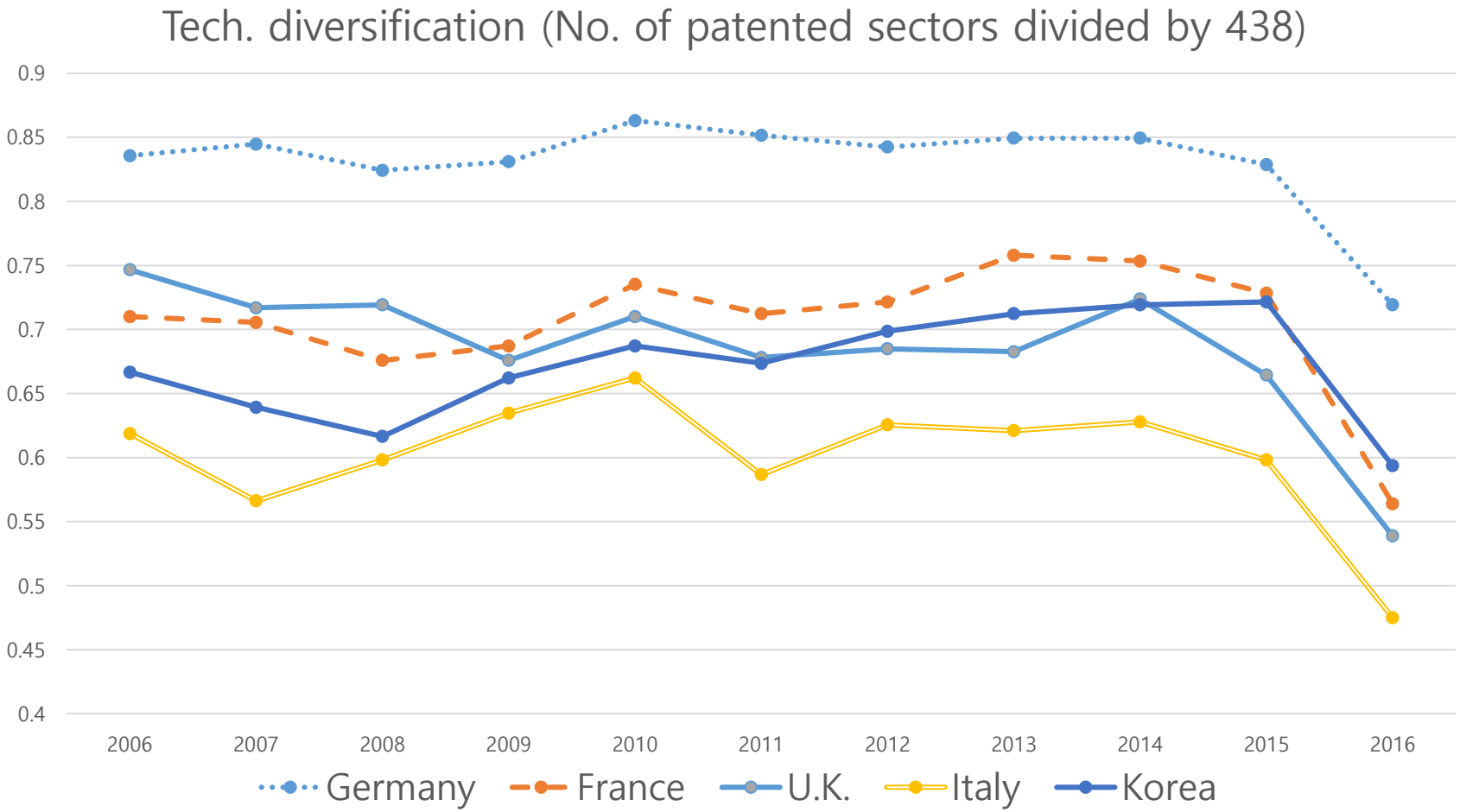
UK = lowest localization = highest internationalization
Germany = high; Korean rapid catch-up



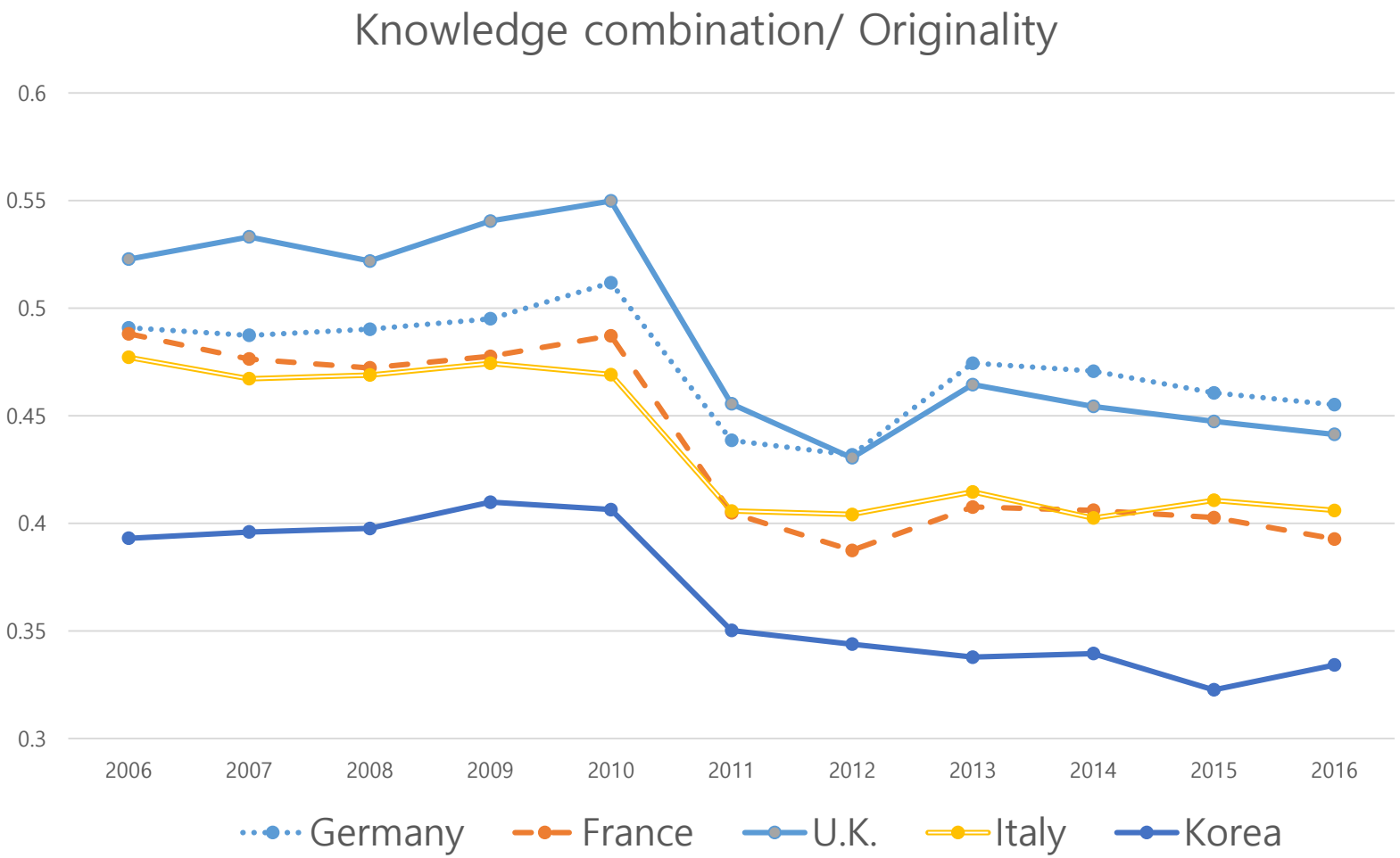
Concentration of Innovation in Korea vs. Balanced in Europe



Germany = most diversified;
Italy = least diversified (ready for 4IR?)



Combination of Knowledge (from wider fields) = Originality (readiness for 4IR): UK, Germany highest; Korea lowest:



Summary of NIS by countries

1) Italy: longest cycle time-based technologies (good for profit & growth)
but low degree of tech. diversification, lower degree of knowledge localization, and medium level of combination

2) **UK: highest originality** and longer cycle tech
but less diversified; lowest intra-national diffusion.
-> maybe, better to try to increase intra-national diffusion (which is lower than Korea); a bit more diversification.

3) Germany: highest diversification and highest localization
relatively high combination and medium cycle time

4) Korea: highest localization and concentration
= nationalistic and big business led NIS
has still yet to catch up in terms of longer cycle tech, diversification, less concentration (too much by Samsung; too Few by SMEs);

5) France = Always in the middle; no clear-cut distinction

Country's Readiness for 4th IR

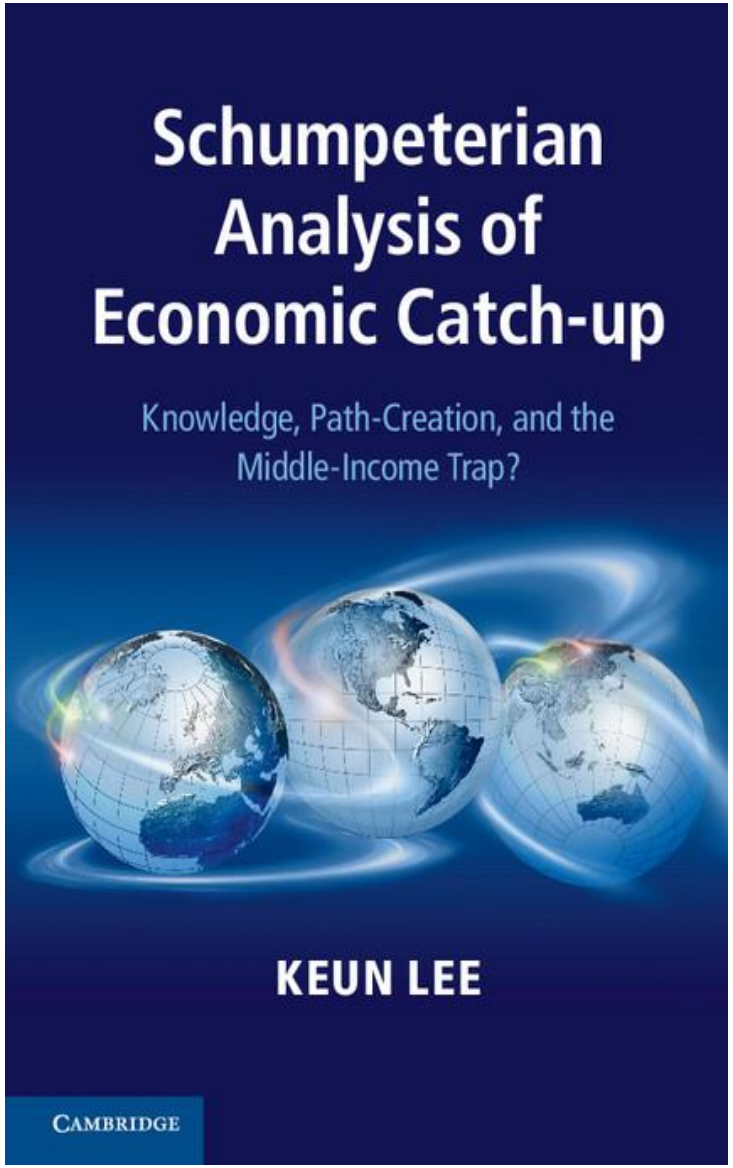
1) Korea
short cycle-tech & Big business based catch-up mode of NIS;
-- low readiness for 4th IR
(lowest combination; medium diversification; lower fusion)

2) Italy = long cycle tech. and Medium sized firm based NIS ;
good basis for profitable growth; but lower readiness for 4th IR
(low combination and lowest diversification)

3) Germany = best ready for 4th IR
(highest diversification; high combination and fusion)

4) UK = ready for 4IR with highest combination
but needs to be more diversified

from NIS to Econ Growth/Catch-up at 3 levels

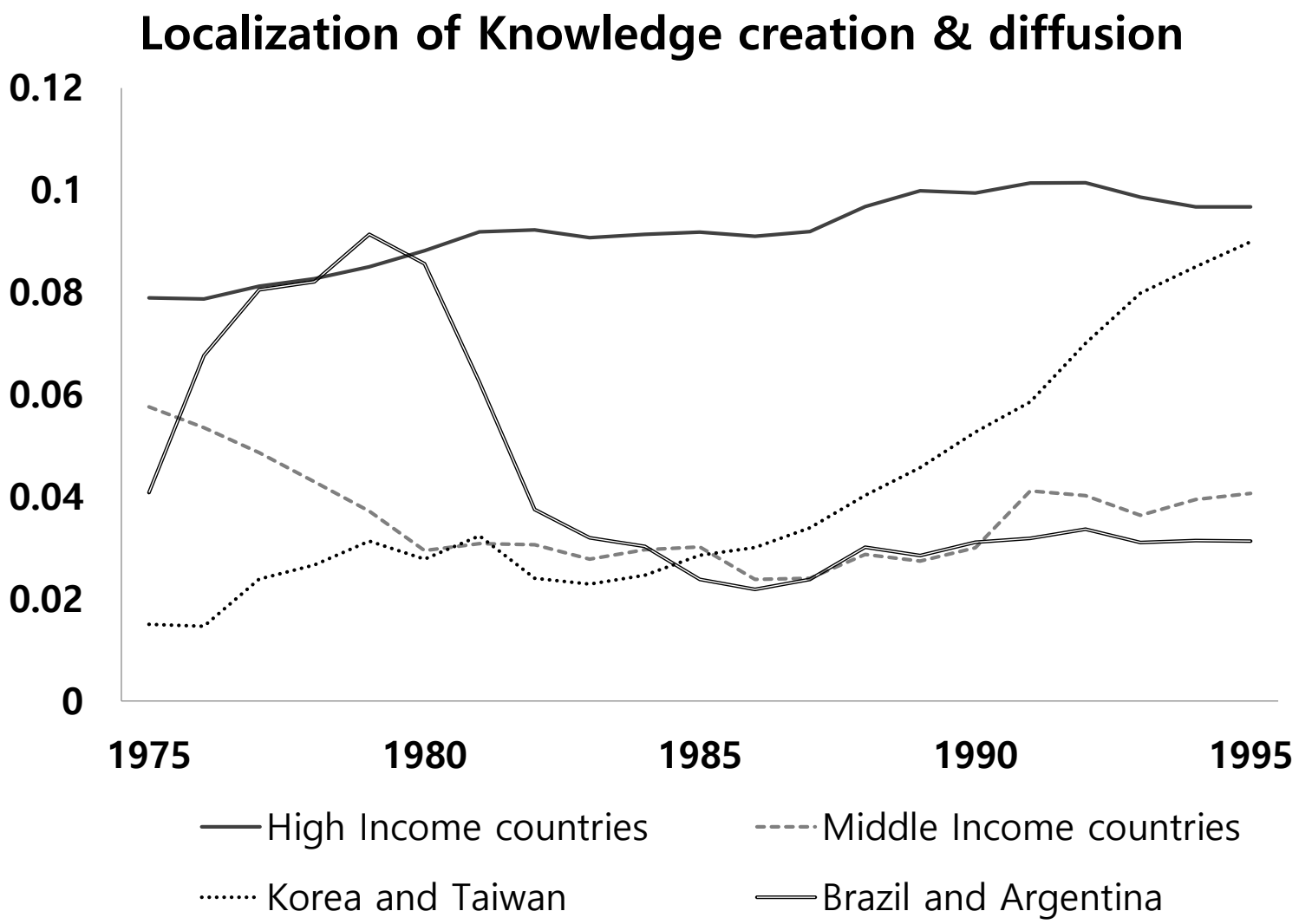


1) **Country: What determines catching-up growth:**
   -> per capita income growth
2) **Sector: Why easy to catch up in some sectors;**
   why not in others ?
   -> Country's US Patent share in sectors
3) **Which the CIS (corporate innovation system) a good fit for catching up;**
   sales growth, profitability, firm value, productivity

=> different question

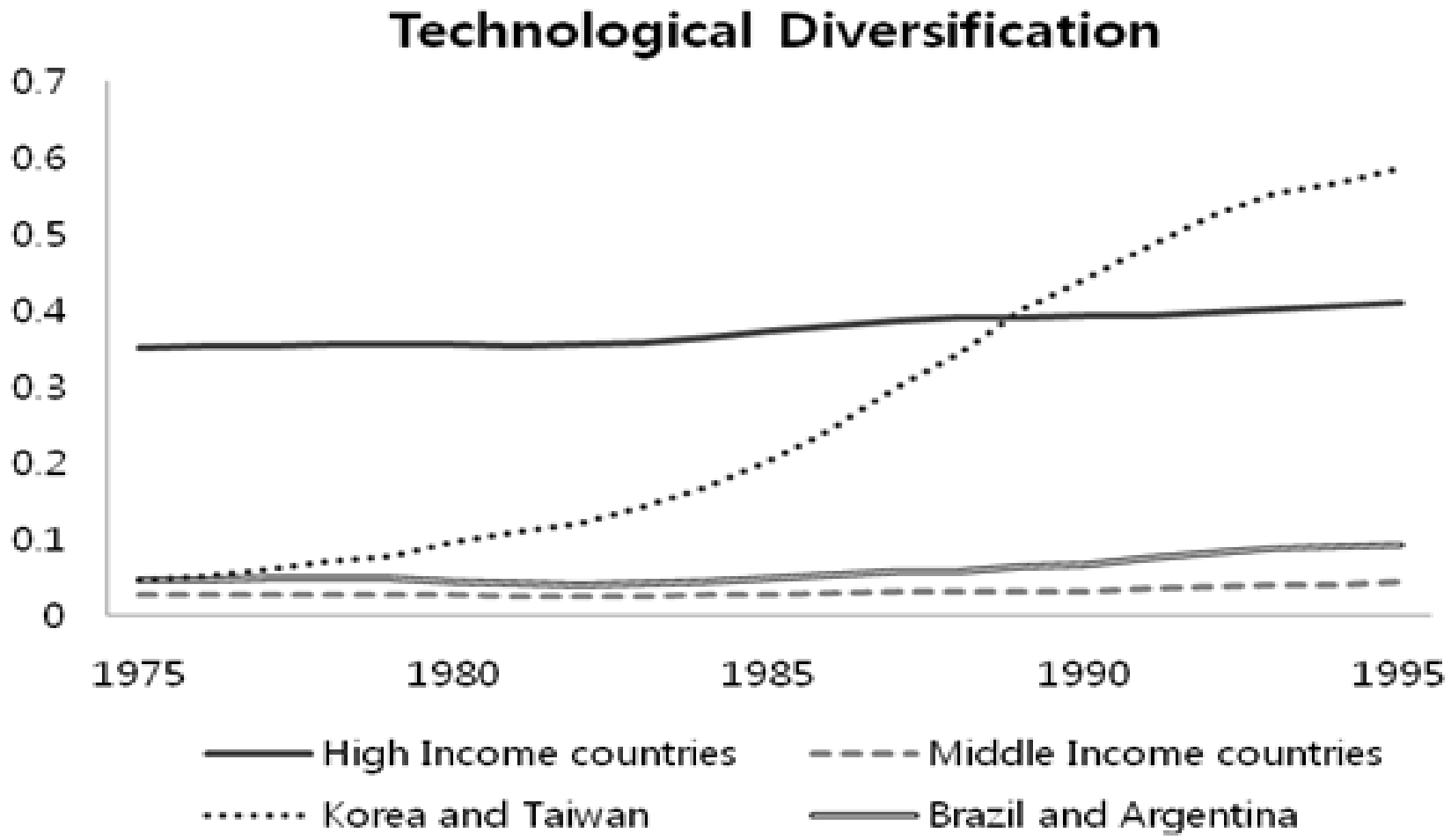
-> same answers = knowledge variables

Intra-national Citation in Patents (~self-citation)

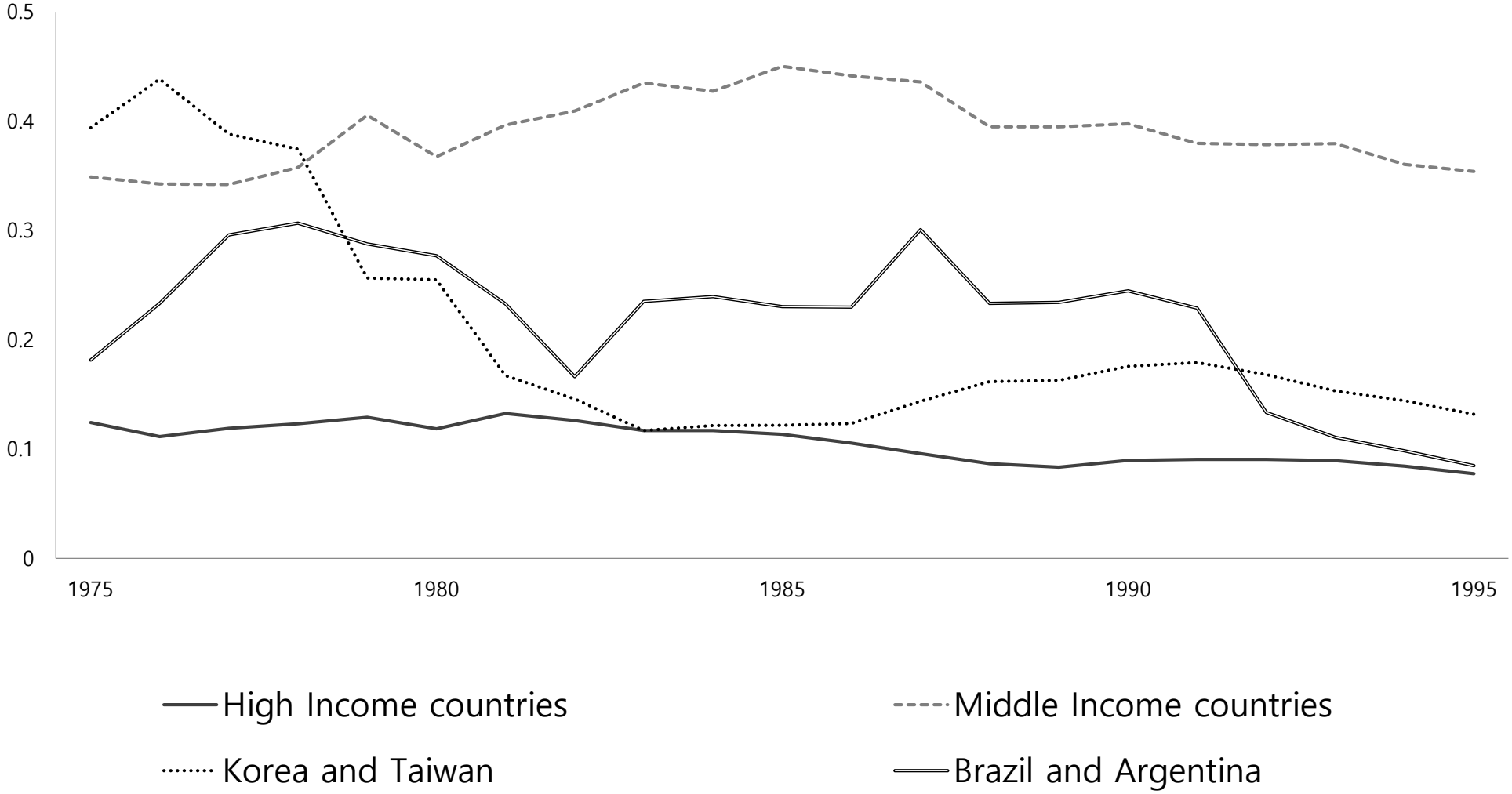


Tech. Diversification = No of sector with patents / 417

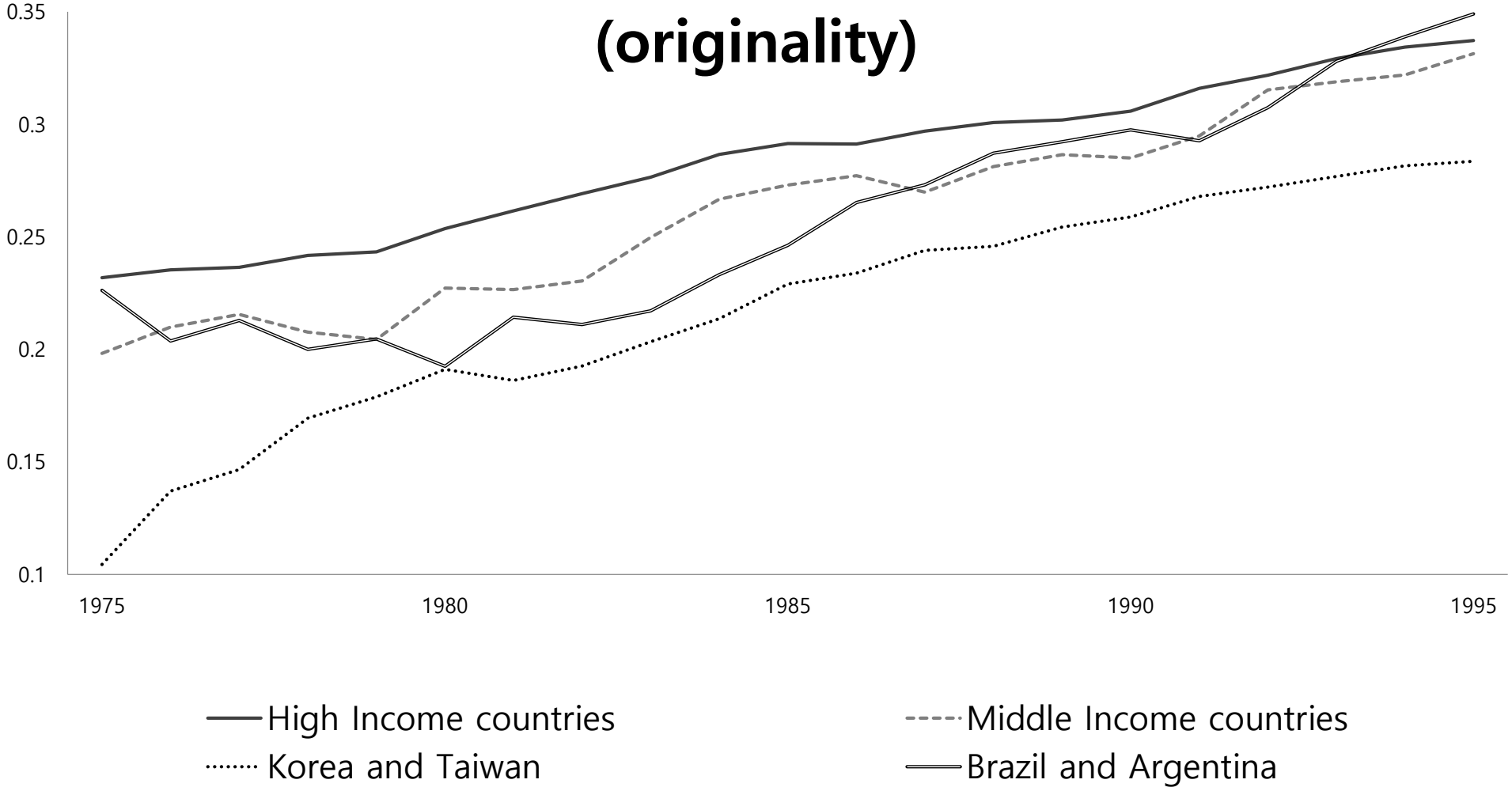
cf) 3 digit in USPTO



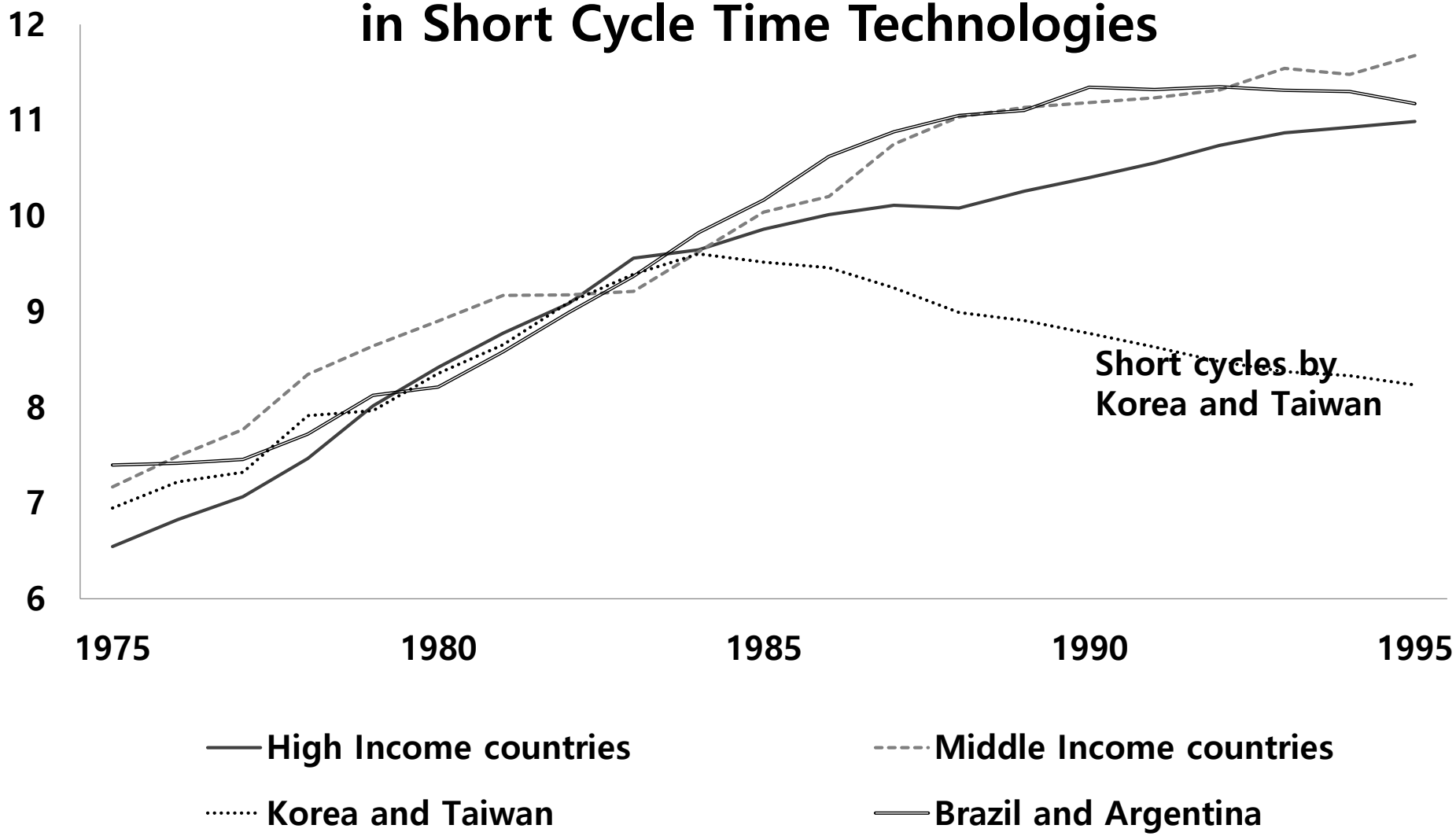
HHI = Index of Concentration in terms of inventors



knowledge combination/Convergence (originality)

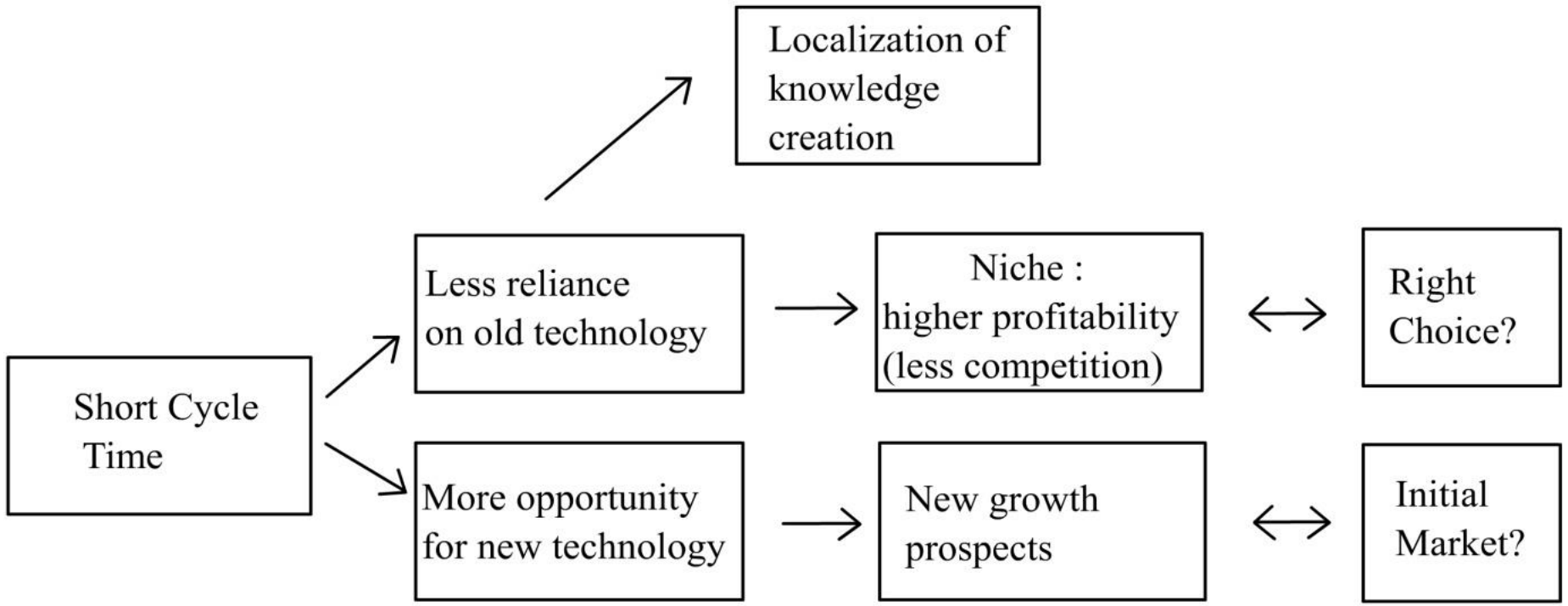


Korean Catching up by Specializing in Short Cycle Time Technologies



Getting into Short cycles -> rapid localization -> Domestic Value chains &diversification

Figure 6-2 : Criterion of Technological Specialization - Why the Sectors of Short Cycle Matter



Top 10 Classes of G5 vs Korea-Taiwan ->no overlap

G5	Class	Class Name	Patent count
1	514	Drug, Bio-Affecting and Body Treating Compositions	10349
2	428	Stock Material or Miscellaneous Articles	3883
3	73	Measuring and Testing	3789
4	123	Internal-Combustion Engines	3479
5	424	Drug, Bio-Affecting and Body Treating Compositions	3389
6	210	Liquid Purification or Separation	2853
7	435	Chemistry: Molecular Biology and Microbiology	2852
8	250	Radiant Energy	2639
9	264	Plastic & Nonmetallic Article Shaping or Treating	2349
10	324	Electricity: Measuring and Testing	2325

Korea-Taiwan	Class	Class Name	Patent count
1	438	Semiconductor Device Manufacturing: Process	1189
2	348	Television	712
3	439	Electrical Connectors	408
4	257	Active Solid-State Devices (Transistors, Solid-State Diodes)	374
5	362	Illumination	374
6	280	Land Vehicles	355
7	365	Static Information Storage and Retrieval	346
8	70	Locks	340
9	360	Dynamic Magnetic Information Storage or Retrieval	313
10	482	Exercise Devices	311

Regressing growth onto National Innovation systems: Asian 4 as benchmark (Lee 2013)

	Asian 4	High Income	middle Inc.	World
Tech cycle time	**(-)***	**(+)***	**(+)***	**(+)***
Localization of knowledge	+	(+)*	+	(+)*
Originality	+	+	+	+
HH: inventor concentration	(-)*	(-)*	(-)*	(-)*
Asian 4 Dummy		(+)*	(+)*	(+) *

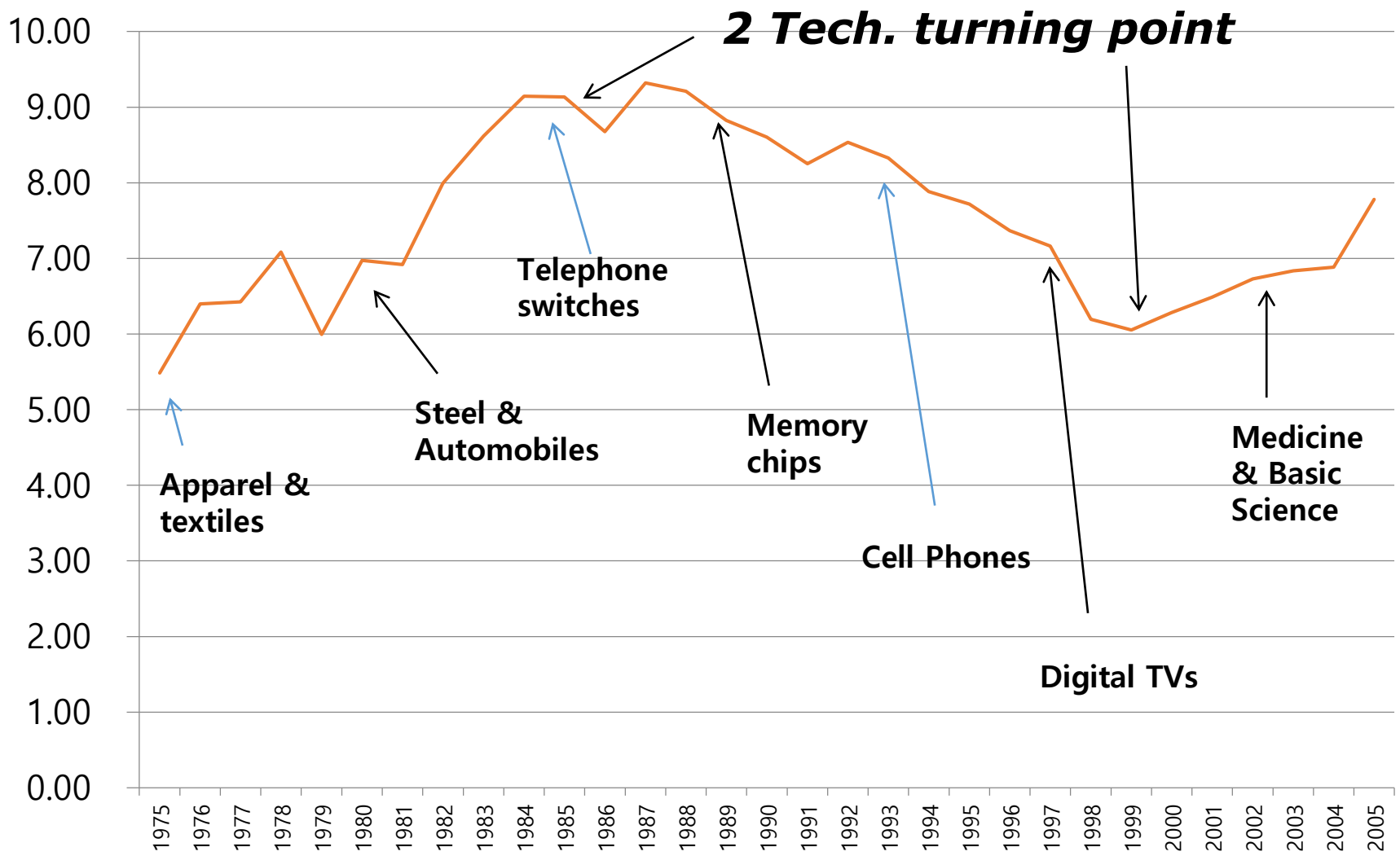
Controls: Initial income, Population, Investment, secondary enrollment

Shorter cycle leading to growth in Asian 4

Korean Detour from Short to long cycle technologies

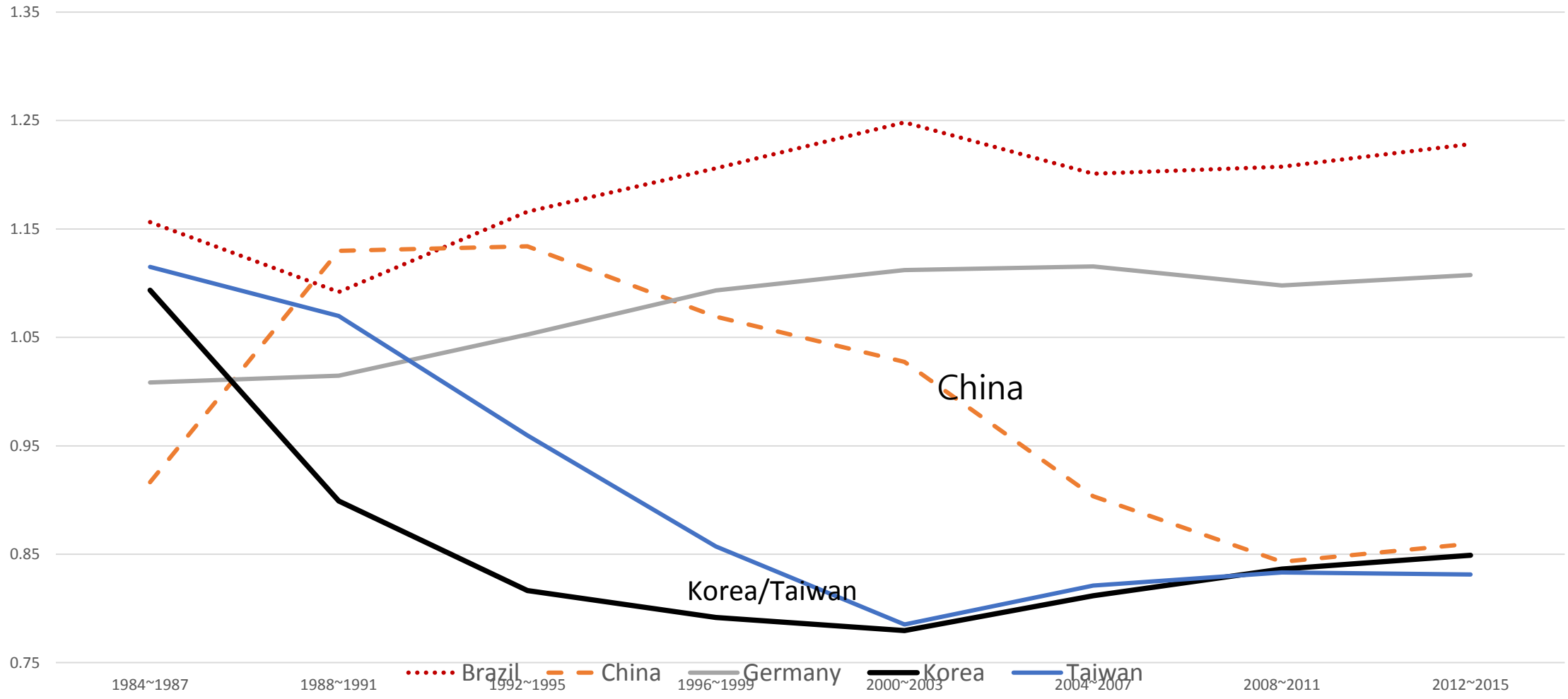
1st in the mid 80s: to short cycle sectors

2nd in the 2000s: to long cycle sectors; ex. Samsung's biosimilar



Similar detour from short to long cyles in China, but not in Brazil

Table Period average cycle time of technologies



NIS around the world
and their clustering
and dynamic change over tme

NIS around the world: Average using the 2011~`15 values

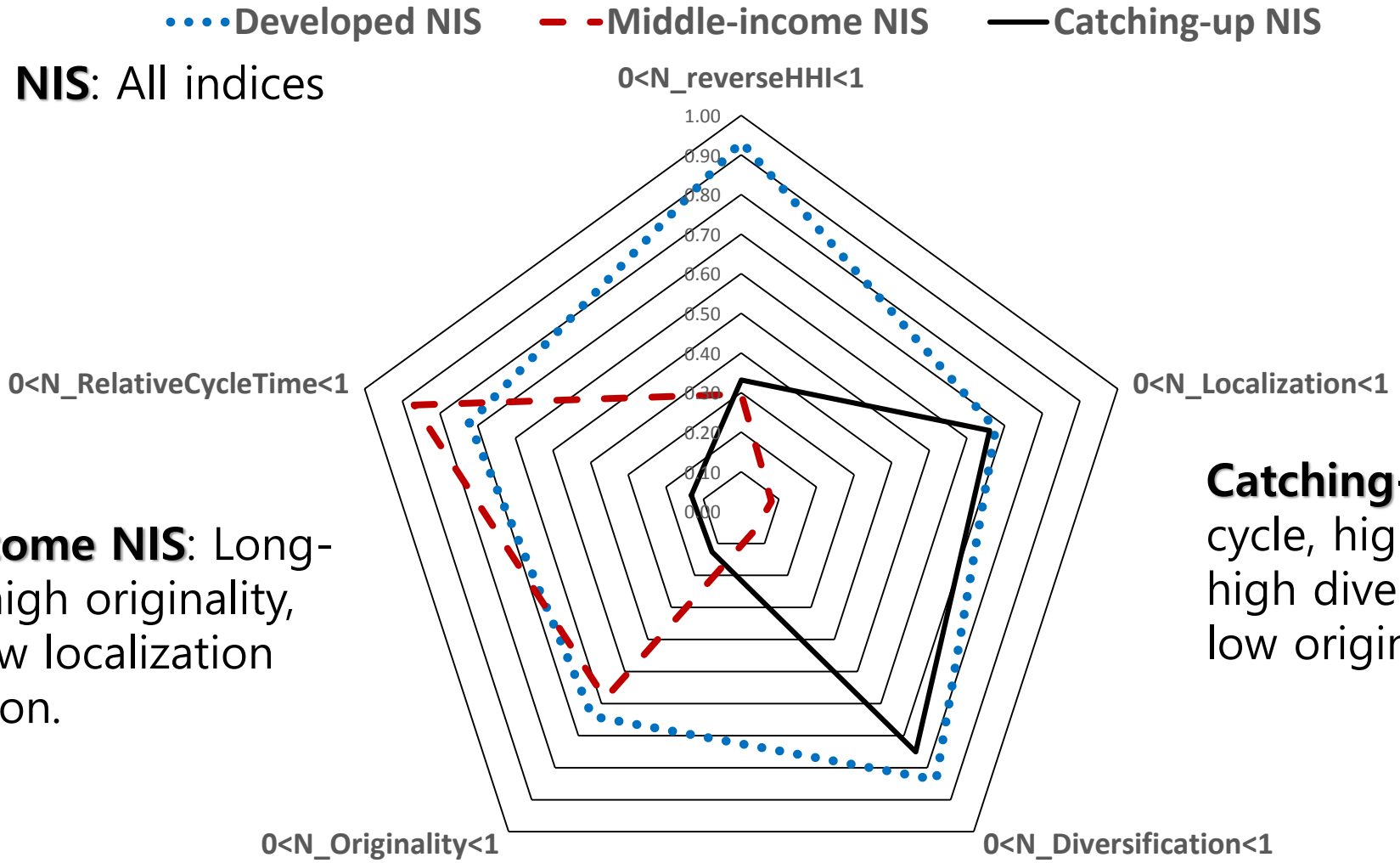
	① 1-HHI	② Localization	③ Diversification	④ Knowledge combination	⑤ Relative Cycle Time	NIS5 =①+②+③+④+⑤
Silicon Valley	0.99	0.69	0.63	0.51	0.87	3.69
United States	0.99	0.25	0.94	0.50	1.00	3.69
Japan	0.98	0.41	0.87	0.35	0.94	3.55
Germany	0.98	0.14	0.84	0.46	1.11	3.53
United Kingdom	0.99	0.07	0.69	0.45	1.16	3.36
France	0.97	0.11	0.73	0.40	1.08	3.31
Italy	0.98	0.09	0.61	0.41	1.16	3.25
Israel	0.99	0.07	0.43	0.50	1.04	3.04
Denmark	0.97	0.08	0.37	0.43	1.17	3.02
Norway	0.99	0.08	0.27	0.48	1.20	3.02
Taiwan	0.97	0.13	0.67	0.33	0.83	2.93
South Korea	0.85	0.14	0.71	0.34	0.85	2.88
Sweden	0.82	0.10	0.57	0.39	0.99	2.87
China	0.94	0.05	0.64	0.33	0.85	2.82
Brazil	0.96	0.02	0.16	0.39	1.24	2.76
Mexico	0.93	0.01	0.10	0.49	1.22	2.74
Finland	0.77	0.10	0.42	0.43	0.98	2.68
India	0.97	0.03	0.24	0.37	1.06	2.67
Hong Kong	0.96	0.04	0.29	0.39	0.98	2.66
Singapore	0.92	0.04	0.32	0.44	0.89	2.60
Chile	0.94	0.01	0.04	0.43	1.18	2.60
Malaysia	0.92	0.04	0.08	0.40	1.13	2.56
Beijing	0.96	0.05	0.36	0.39	0.8	2.56
Shenzhen	0.85	0.05	0.39	0.33	0.9	2.52
Argentina	0.91	0.04	0.03	0.39	1.14	2.51
Thailand	0.82	0.01	0.03	0.47	1.11	2.44
Russsia	0.89	0.04	0.10	0.42	0.93	2.39

Clustering the NIS around the world

Cluster	① 1-HHI	② Localization	③ Diversification	④ Knowledge combination	⑤ Relative Cycle Time	NIS5 =①+②+③+④+⑤
Developed NIS: 4 EU C's	0.983	0.103	0.719	0.429	1.127	3.36
Catching-up NIS (Asian tigers)	0.930	0.077	0.527	0.365	0.879	2.78
Middle-income NIS (Brazil, Argentina, Chile, Mexico, Thailand, Malaysia)	0.91	0.02	0.07	0.43	1.17	2.60
Shenzhen	0.85	0.05	0.39	0.33	0.9	2.52
Silicon Valley	0.99	0.69	0.63	0.51	0.87	3.69
Israel	0.99	0.07	0.43	0.50	1.04	3.03

- In developed NIS and Silicon Valley, most indices are highest.
- In catching-up NIS, localization and diversification high; but in short cycle time.
- In MIC NIS; very low localization & diversification but in long cycles

The 3 NIS compared (using normalized values): catch-up NIS = detour for the Dev'd (mature) NIS



Developed NIS: All indices are high.

Middle-income NIS: Long-cycle and high originality, but very low localization diversification.

Catching-up NIS: short-cycle, high localization, and high diversification, but low originality.

Dynamic Change of the NIS over time: why the detour makes sense; emergence of the Catching-up NIS: Cluster Analysis (JH Lee 2018)

Period	G1	G2 (MICs)		G3	G4 (EU4)	G5 (Catch-up)	G6	G7
1988-1991	Argentina Malaysia	Brazil China Denmark Finland Hong Kong	India Mexico Norway Singapore South Korea Taiwan	Chile Thailand	France Germany Italy, UK Sweden	-	Japan	US
1996-1999	Argentina	Brazil China Denmark Finland Hong Kong India	Malaysia Mexico Norway Singapore Thailand	Chile	France Germany Italy, UK Sweden	South Korea Taiwan	Japan	US
2004-2007	-	Argentina Brazil Chile China Denmark Hong Kong	India Malaysia Mexico Norway Singapore Thailand	-	France Germany Italy, UK Sweden	Finland South Korea Taiwan	Japan	US
2008-2011	-	Argentina Brazil Chile Denmark Hong Kong India	Malaysia Mexico Norway Singapore Thailand	-	France Germany Italy, UK Sweden	China Finland South Korea Taiwan	Japan	US

NIS vs. Complexity to economic growth, '99-15 (JH Lee 2018)

Dependent: 4 year average of annual growth of GDP per capita	(1)		(2)		(3)		(4)	
	b	t	b	t	b	t	b	t
Log of initial GDP per capita	-0.091***	-7.50	-0.083***	-6.66	-0.088***	-7.36	-0.069***	-6.58
Growth rate of population	-1.26	-1.53	-1.31	-1.61	-1.28	-1.57	-1.24	-1.26
Fixed capital investment per GDP	0.39***	4.52	0.40***	4.64	0.40***	4.72	0.35***	3.53
Enrollment :secondary education	0.011	0.90	0.013	1.04	0.0060	0.50	-0.0053	-0.46
NIS3 (diver+origi+cycle)	0.095***	3.35						
NIS4 (local+decent+origi+cycle)			0.062**	2.05				
NIS5					0.066***	2.73		
ECI (econ. Complexity)							0.019**	2.67
Constant	0.74***	7.43	0.64***	5.75	0.68***	7.45	0.62***	6.35
adj. R-sq	0.36		0.34		0.36		0.31	
N	171		171		171		159	

Both NIS & Complexity significant to Economic growth

Dependent: 4 year average of annual growth of GDP per capita	(1) 83~15		(2) 83~99		(3) 99~15	
	b	t	b	t	b	t
Log of initial GDP per capita	-0.056***	-8.29	-0.11***	-4.56	-0.083***	-6.77
Growth rate of population	-0.93**	-2.52	-0.71	-0.67	-1.12	-1.3
Fixed capital investment per GDP	0.25***	5.67	0.36***	4.08	0.36***	4.11
Enrollment: secondary education	0.0098	0.81	0.072***	3.76	0.002	0.17
NIS4	0.053***	4.24	0.058***	3.68	0.057**	2.2
ECI	0.013**	2.55	0.0035	0.2	0.016**	2.38
Constant	0.39***	7.86	0.78***	4.01	0.63***	6.97
adj. R-sq	0.28		0.36		0.35	
Observations	294		135		159	
Groups	40		38		40	
Hausmann	49.02***		33.28***		35.99***	

- NIS5 = Localization + decentralization + Originality + Diversification + Relative cycle time

Concluding Remarks/ Implications

- NIS/RIS can be measured by patent data: 5 Variables:
  -- Knowledge combination and diversification Vars (highest in Germany)
  = readiness for the 4th Industrial Revolution

- Higher NIS index -> higher economic growth cf) complexity;
  -- but upgrading of NIS is not linear but involves detours

- Could identify different NIS groups by clustering analysis
and a dynamic changes in the patterns of NIS:
-- from the MIC NIS to mature/developed NIS via Catching up NIS
(eg e. Asia in short cycle technologies) ➔ detour strategy (Lee 2019 book)
- importance of detour **(from short to long cycle tech)** for effective catch-up

- Similar variables can be measured for NIS, RIS, CIS

Thank you!

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