

# Korea's Co-Patenting Networks: Main features and policy implications

# C O N T E N T S



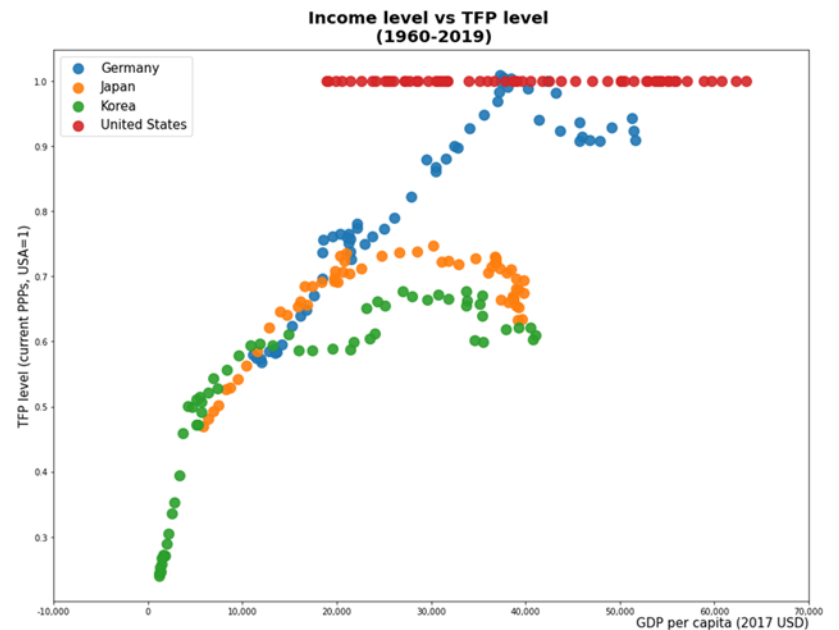
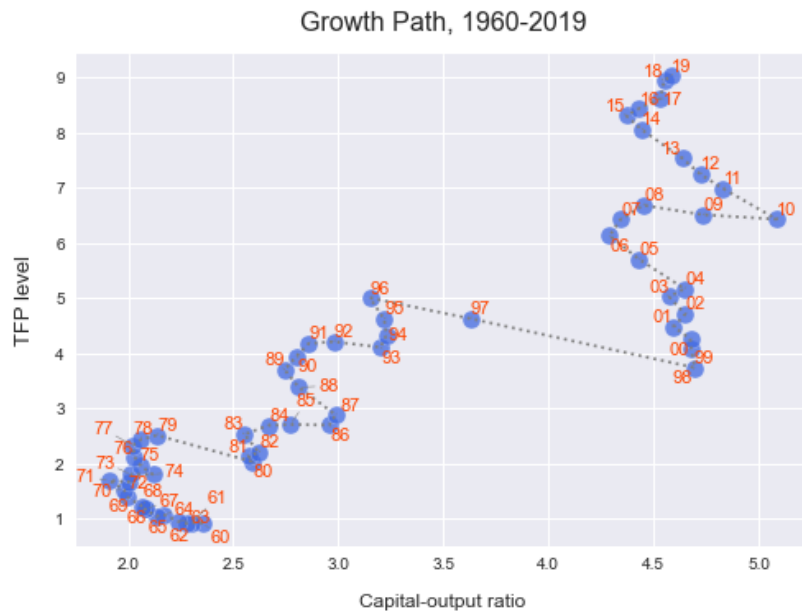
**Part 1. Trend of Co-Patenting in Korea**

**Part 2. Key Features of Co-patenting Networks**

**Part 3. Policy Implications**

**Appendix: Korea in the Global VC Network**

# Development Path of Korea

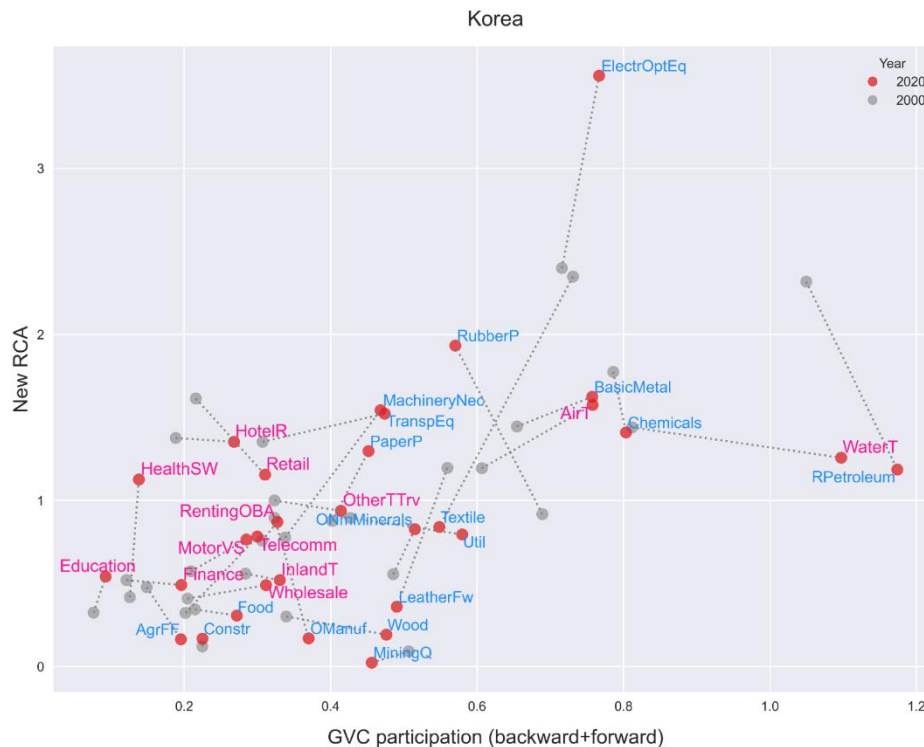


(Data source: PWT 10.0)

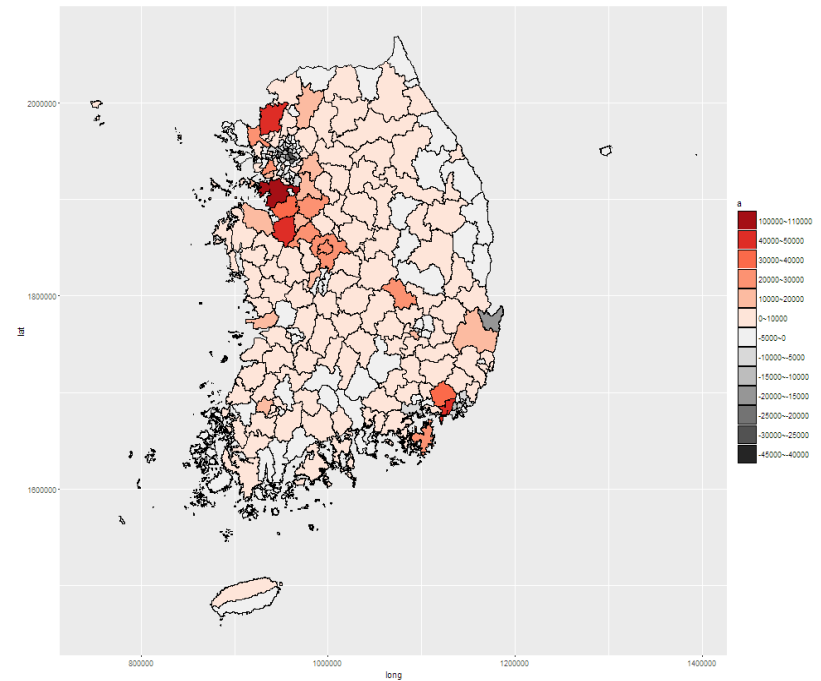
# Challenges facing Korea's regional economies

Manufacturing industries climb up the technology ladder. This corresponds to:

- ① Increasing tendency of hyper-specialization in international trade
- ② Regional agglomeration of high-tech sectors, which in turn encroaches the growth base of many local economies

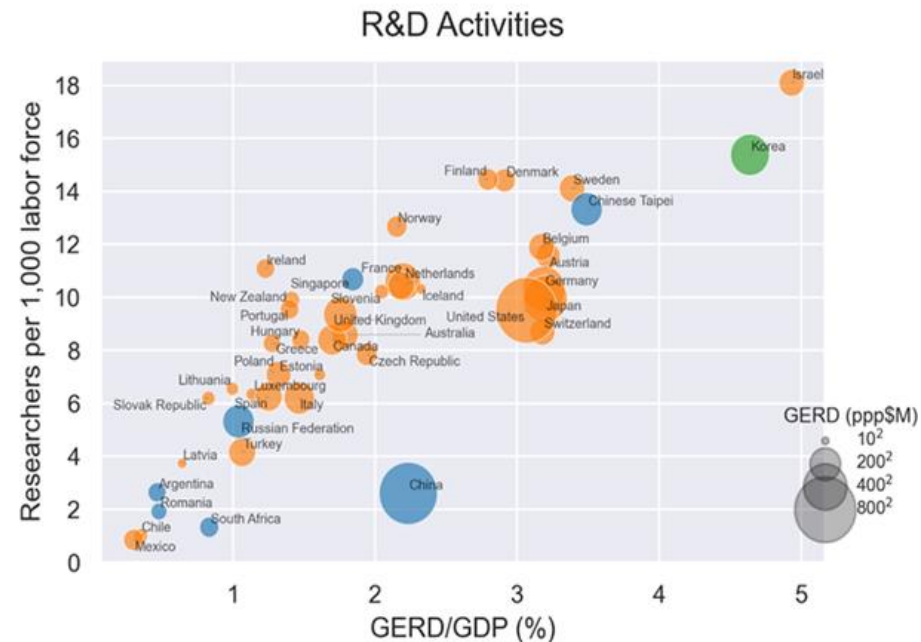


## Regional agglomeration of high-tech manufacturing



# Korea's transition to an innovation economy

- Despite high R&D spending, the distance to frontier is not narrowing
  - Network perspective would offer a clue to this puzzle
- ① Korea's position at the global venture capital network shows limitations of state-led innovation economy
  - ② Korea's **co-patenting network** reveals systemic nature of national/regional innovation systems



Part 1

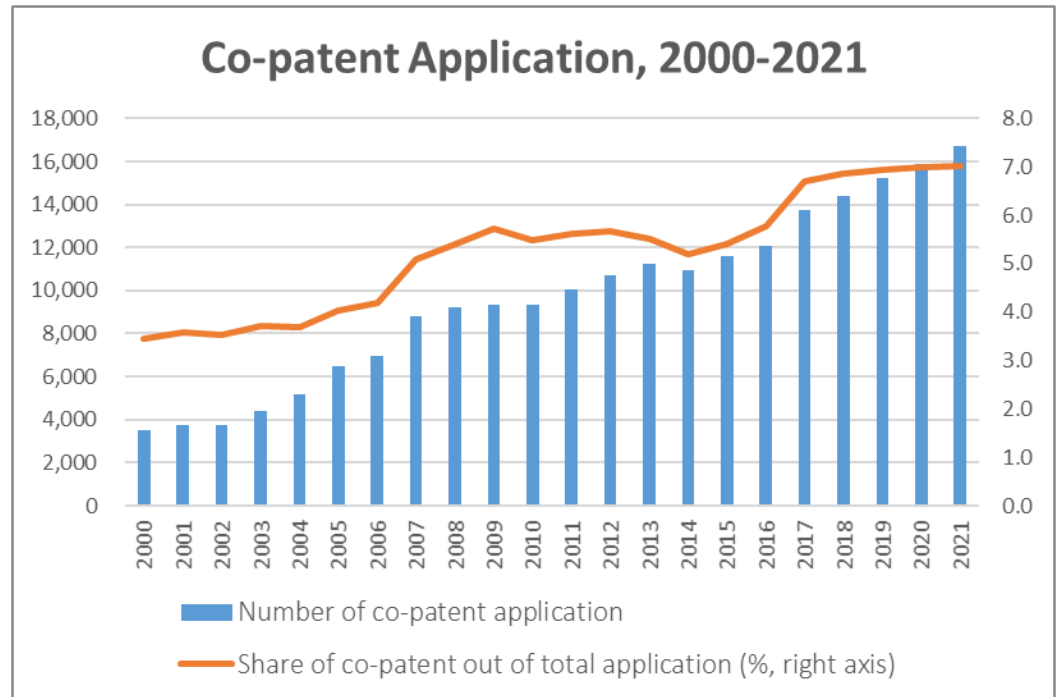
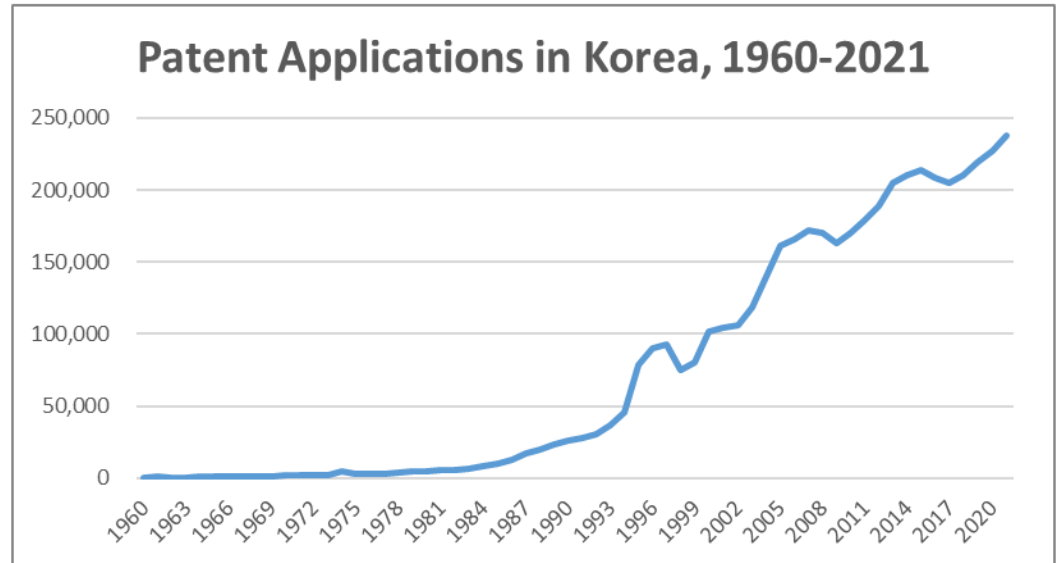
# Co-Patenting Trend in Korea

KDI

# Rapid increase in patenting, along with co-patenting

- All patent data are from the Korean Intellectual Property Office (KIPO)
- KIPO is a member of IP5

- ✓ Data for 2016-2021, disambiguation of names and affiliations;
- ✓ but the general findings are valid.



# Co-patenting data by region

- ① Three regions (Seoul, Gyeonggi, Daejeon) are leading → “Core”
- ② Co-patenting is **highly localized** → next slide
- ③ Foreign applications are increasing, with foreign co-inventors

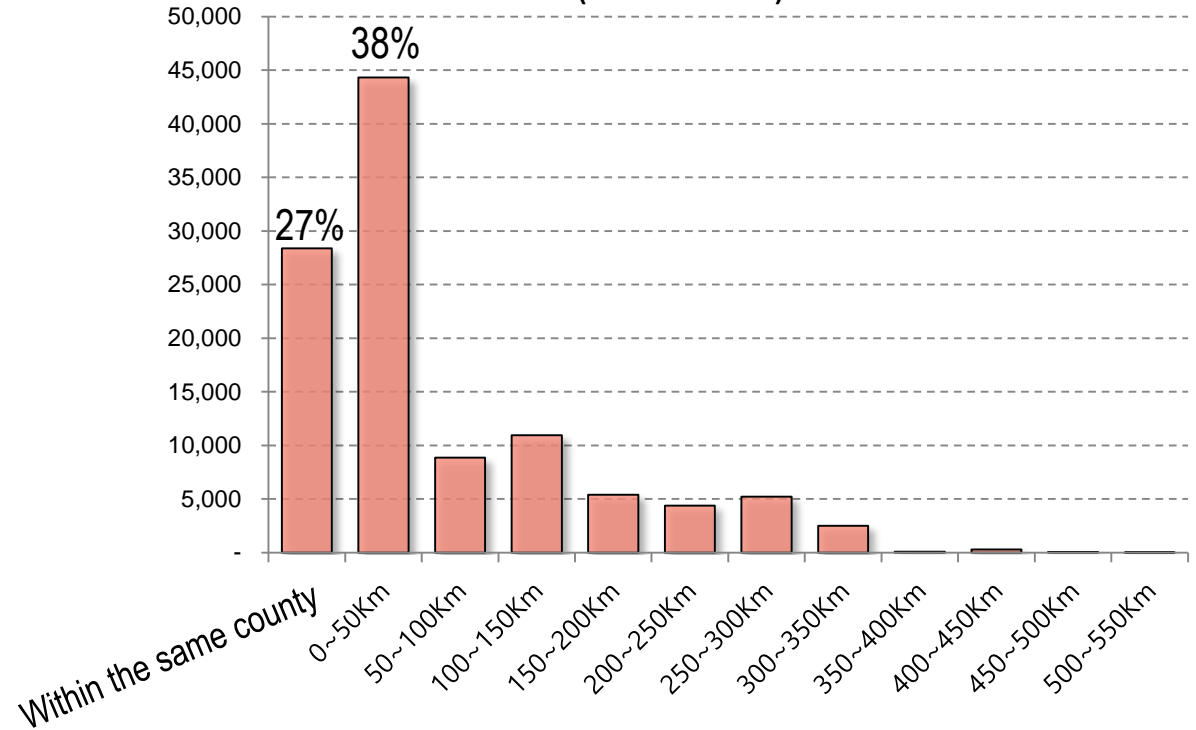
## Co-inventor (Target)

		Seoul	Gyeonggi	Daejeon	Rest of Korea	Foreign	Total	
Inventor (Source)	Seoul	40,314	8,989	2,815	11,435	1,121	64,674	30.3%
	Gyeonggi	10,444	13,148	2,495	7,744	2,048	35,879	16.8%
	Daejeon	4,280	3,523	3,125	4,081	215	15,224	7.1%
	Rest of Korea	6,536	6,227	2,064	33,014	1,192	49,033	23.0%
	Foreign	909	645	131	1,005	45,759	48,449	22.7%
	Total	62,483	32,532	10,630	57,279	50,335	213,259	
		29.3%	15.3%	5.0%	26.9%	23.6%		



2/3 of co-patenting are within 50km

Distribution of distance between inventors & co-inventors (2000-2015)



	Seoul-Seoul	Seoul-GG	Seoul-DJ	Seoul-RoK	GG-GG	GG-DJ	GG-RoK	DJ-DJ	DJ-RoK	Rest of Korea	F-Korea	F-F
2000	508	205	149	190	119	170	149	22	76	547	120	1,251
2005	783	600	512	342	340	452	333	80	174	773	247	1,833
2010	1,522	992	273	811	588	192	720	146	394	1,479	296	1,895
2015	1,742	1,029	381	1,090	969	232	820	175	301	2,200	432	2,204
2020	4,624	1,453	516	1,553	732	262	922	232	403	2,248	379	2,553
2021	4,761	1,547	515	1,702	828	300	986	253	376	2,140	425	2,893

# Changes in B-U-R partnership in co-patenting

- ① B-B is increasing and takes the largest share
- ② Increasing role of universities: with business, & U-U
- ③ Decreasing role of research inst.; very weak in R-R

source	Business Enterprises			Universities			Research Institutes		
	B	U	R	B	U	R	B	U	R
2000	1,070	57	266	68	1	3	316	12	7
2005	2,046	265	245	219	108	44	929	128	24
2010	3,591	891	315	670	249	97	366	236	26
2015	4,130	1,206	322	1,137	424	212	276	242	57
2020	6,943	1,561	278	763	915	244	218	432	118
2021	7,145	1,633	318	878	951	232	294	411	66

# Changes in business enterprises

- ① SME – SME
- ② SME – universities
- ③ SME – RI & Public

source	Small & medium enterprises						
target	SME	LE	BG	Univ	Res Inst	Public	Others
2000	451	42	21	29	24	18	19
2010	1497	209	102	264	132	93	73
2020	<b>2072</b>	200	178	<b>625</b>	<b>211</b>	<b>204</b>	135
2021	<b>2197</b>	180	193	<b>664</b>	<b>242</b>	<b>247</b>	159

- ① LE – SME
- ② LE – LE
- ③ LE - universities

source	Large enterprises						
target	SME	LE	BG	Univ	Res Inst	Public	Others
2000	105	36	21	6	17	6	32
2010	237	158	48	84	24	14	14
2020	<b>251</b>	<b>185</b>	54	<b>174</b>	13	4	35
2021	<b>279</b>	<b>138</b>	53	<b>132</b>	23	2	35

- ① BG – BG
- ② BG – universities

✓ RI's role is minor

source	Business Groups						
target	SME	LE	BG	Univ	Res Inst	Public	Others
2000	76	38	280	22	225	11	54
2010	249	199	892	543	159	7	141
2020	345	291	<b>3367</b>	<b>762</b>	54	29	100
2021	363	291	<b>3451</b>	<b>837</b>	53	7	131

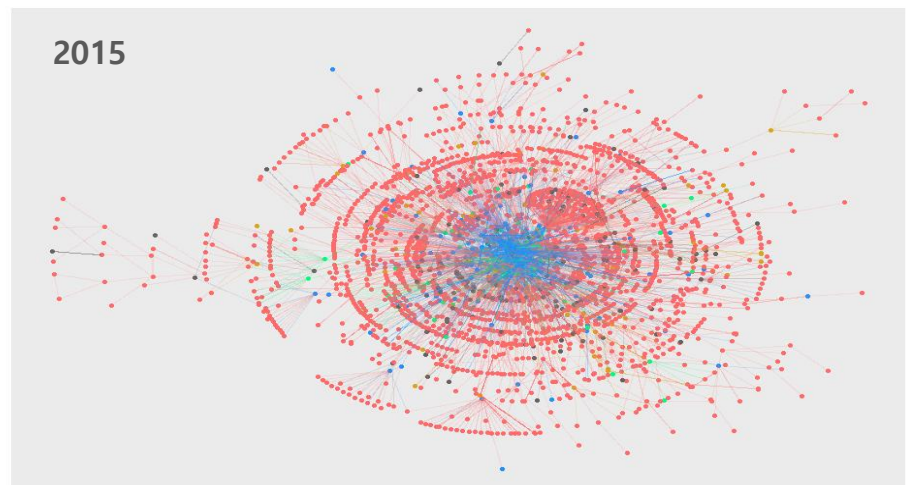
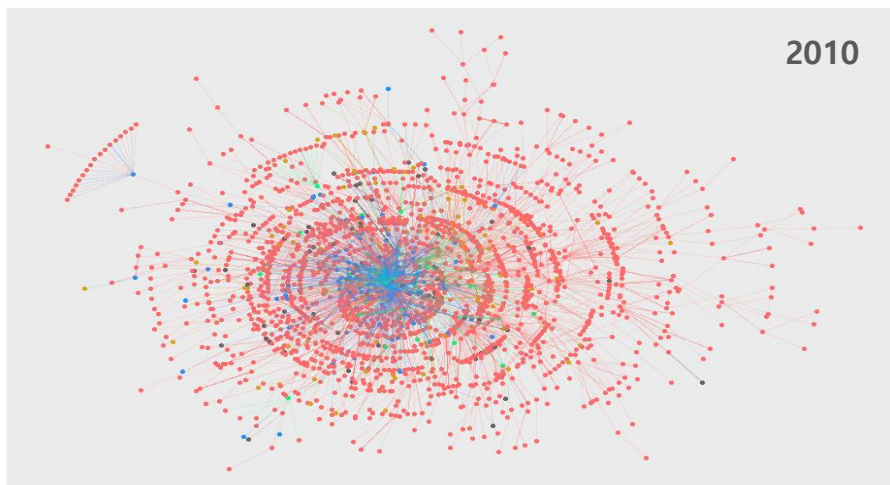
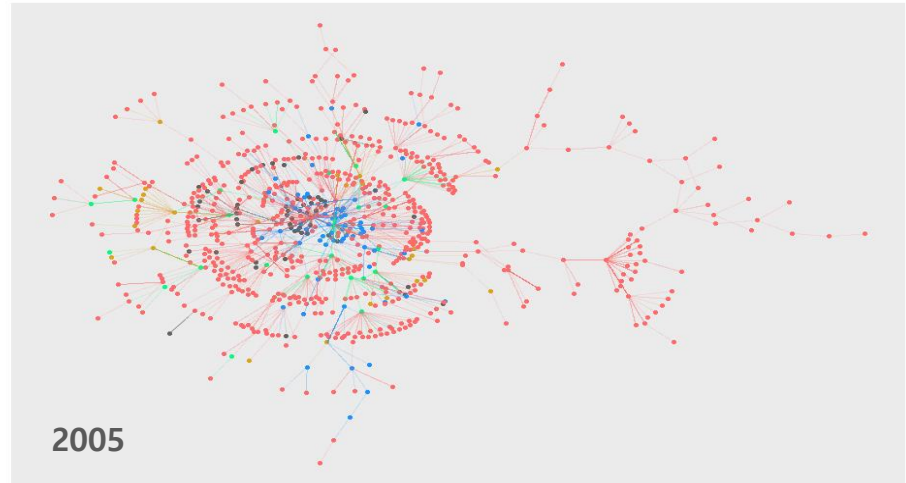
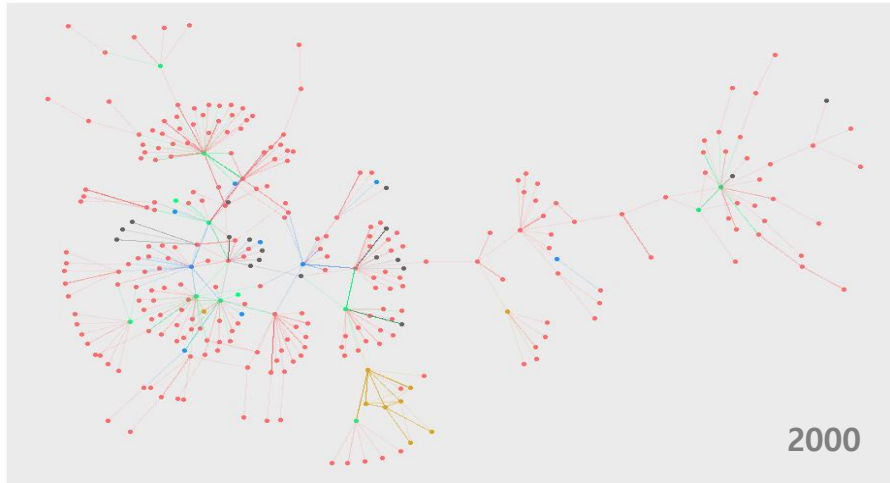
Part 2

# Key features of Co-PAT NW

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## The evolution of Korea's co-patenting network : backbone image of NIS

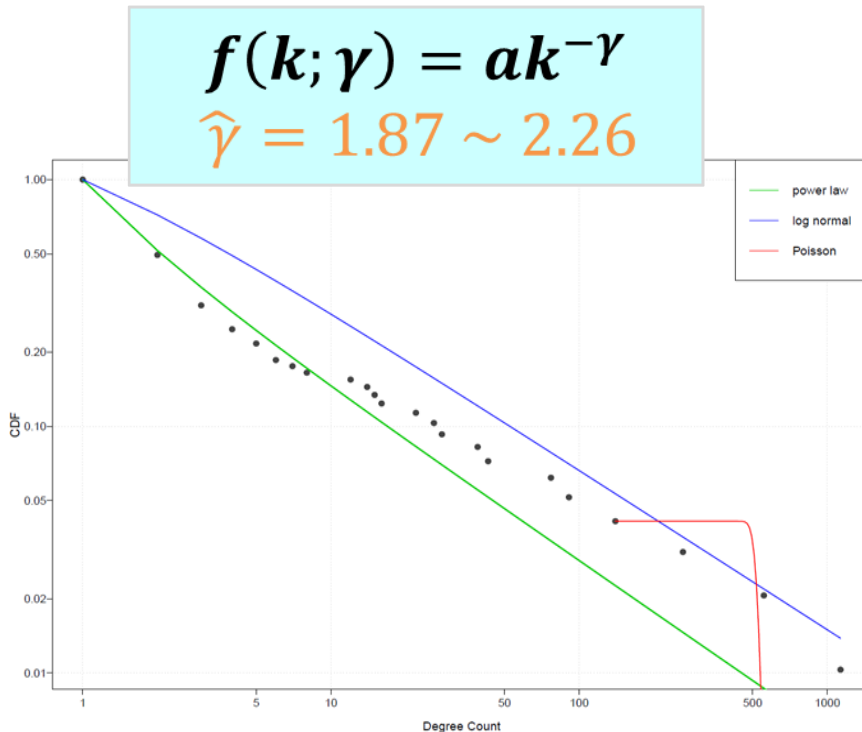
- More complex: typical complex network of power-law degree distribution
- Multiple actors: business enterprises (SMEs, LEs & BGs), universities, research institutes, & foreign inventors (universities – Korean BGs)



# Macro-structure of network

Estimating power-law of degree distribution, by region/tech, shows

- Korea's co-patenting networks lie between an anomalous network and a small world network
- Which implies the mechanism of preferential attachment underlying networks



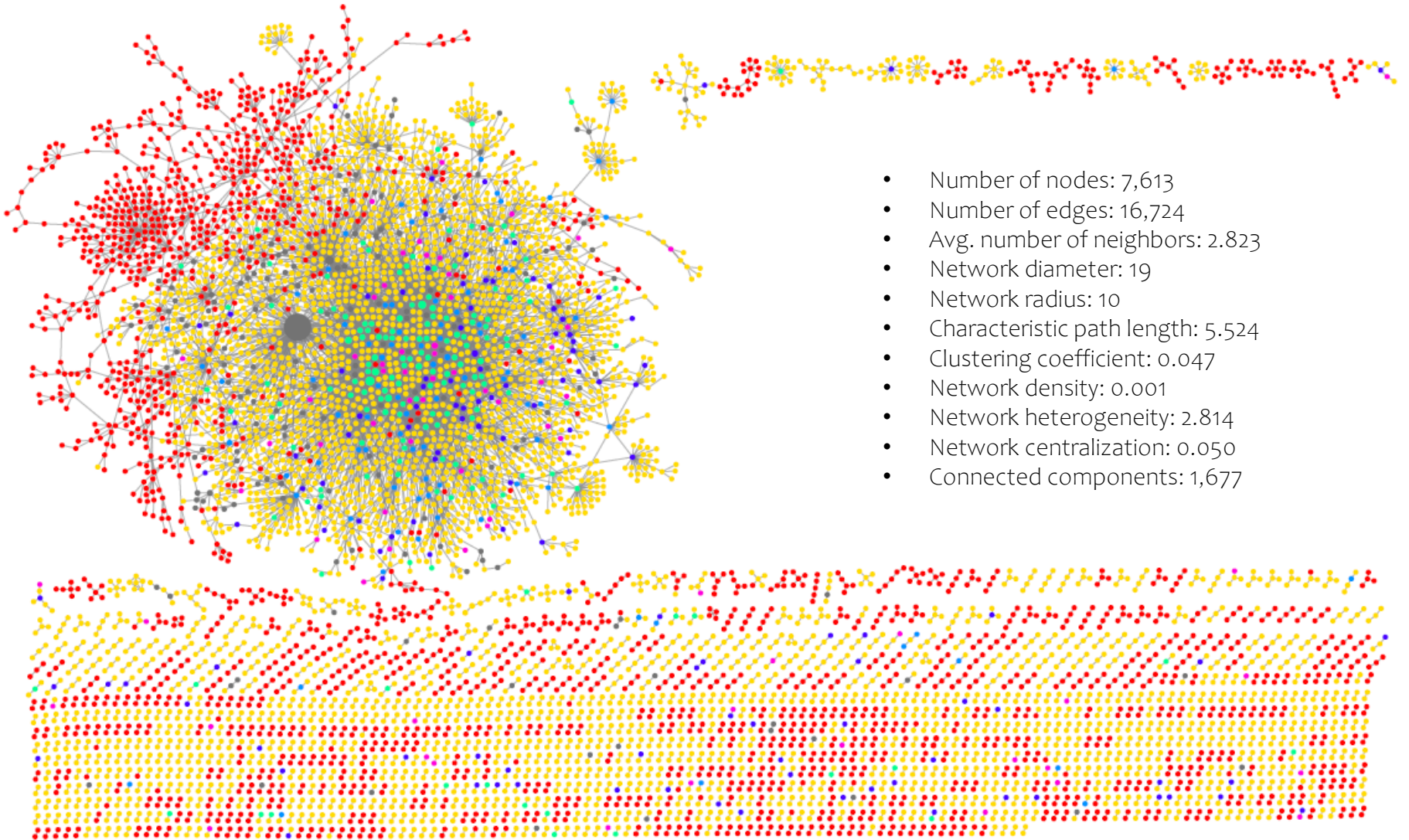
The  $\gamma$ -dependent properties of scale-free networks

	Anomalous regime	Scale-free regime	Random regime
Key feature	No large networks can exist here	Ultra-small world	Small world
Value of $\gamma$	$\gamma < 2$	$2 < \gamma < 3$	$\gamma > 3$

(Source: Barabasi, 2016, chapter 4)

## Co-patenting network, 2021

- The largest component takes 47% of nodes, 76% of edges
- 1,677 isolates are mostly **business enterprises** and **foreign entities**



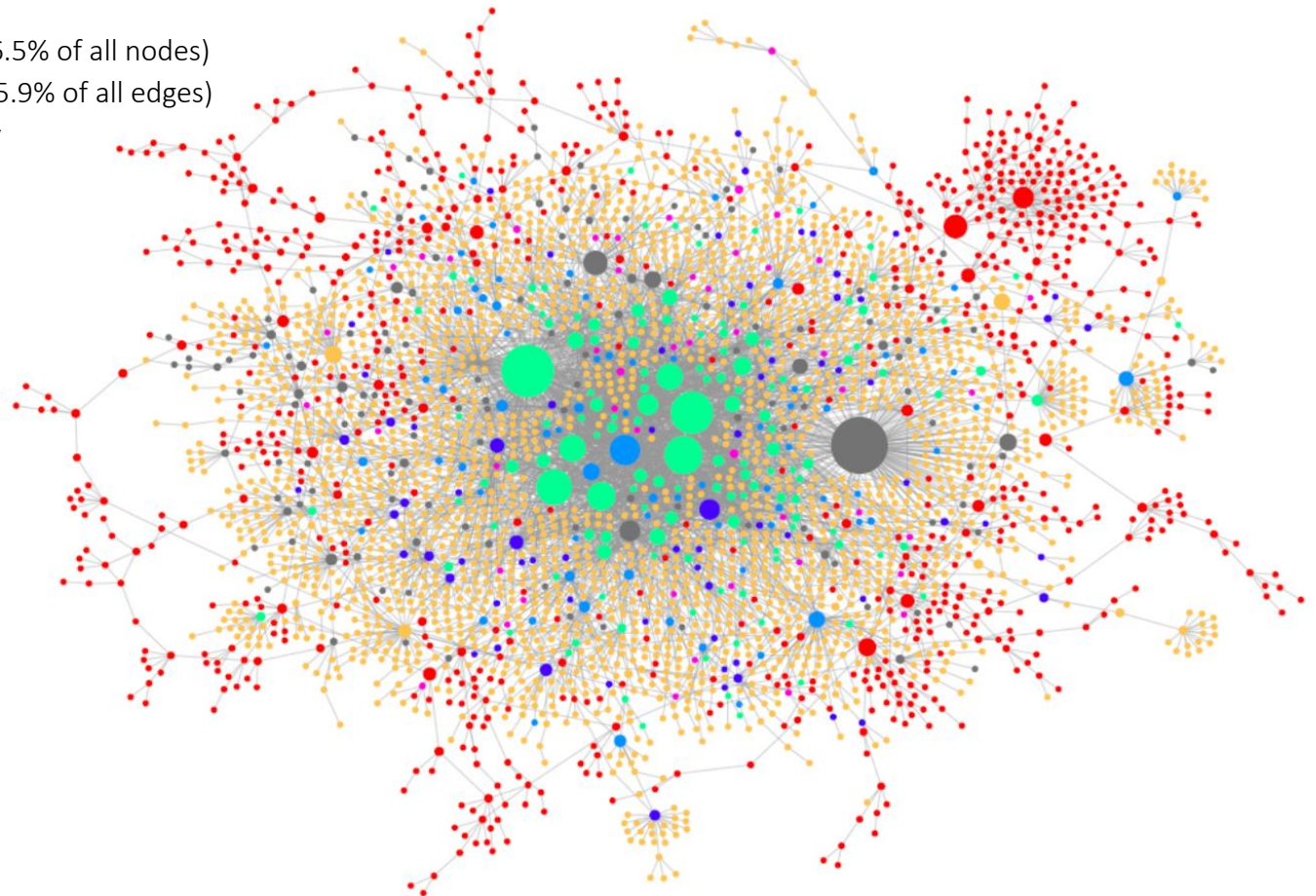
## Co-patenting network 2021, the largest component

- Core of network is composed of small number of U, RI, and BG
- Business enterprises are ① majority, ② BGs are a bridge-role, ③ weak link with RIs
- Centrality of universities is high (& increasing); U-B partnership becomes stronger
- Role of research institutes becomes less central
- Foreign entities are ① increasing, but ② at periphery, ③ weak link with domestics

- Number of nodes = 3,545 (46.5% of all nodes)
- Number of edges = 12,692 (75.9% of all edges)

○ size = between-ness centrality

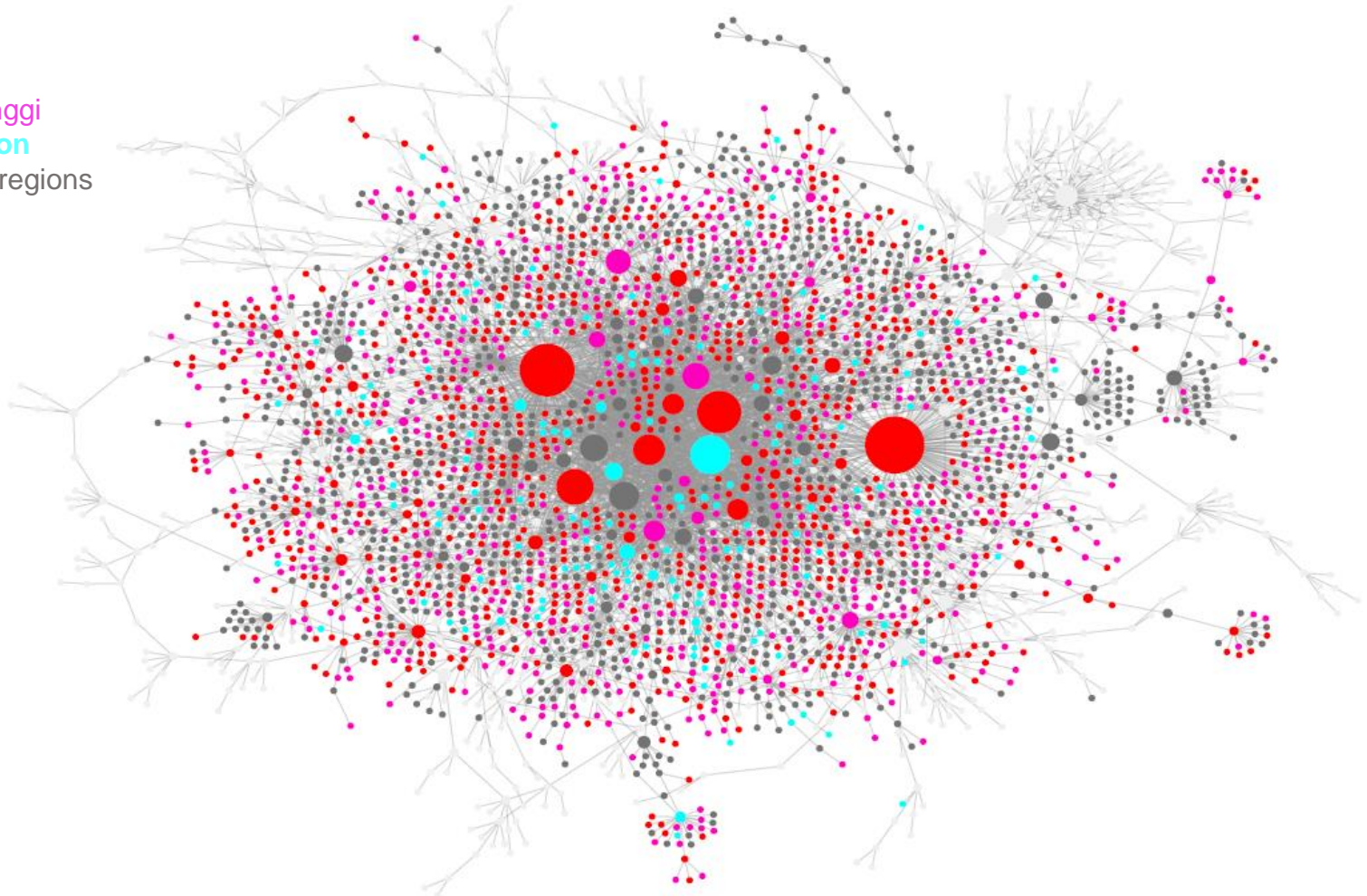
- Private enterprises
- Business groups
- Universities
- Research Inst.
- Public entities
- Other domestic
- Foreign





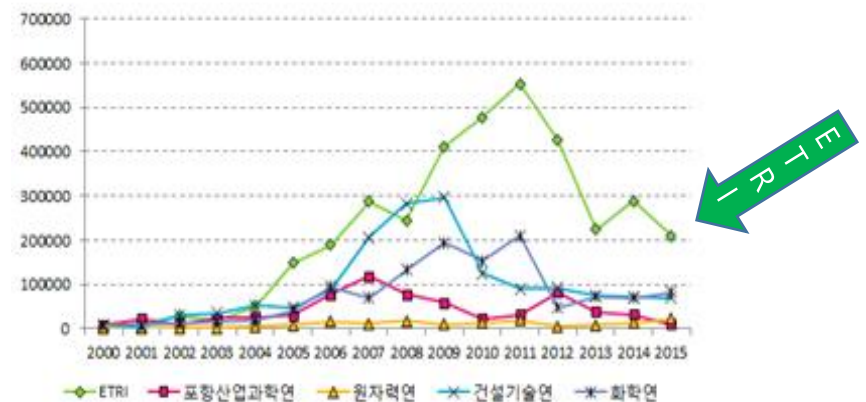
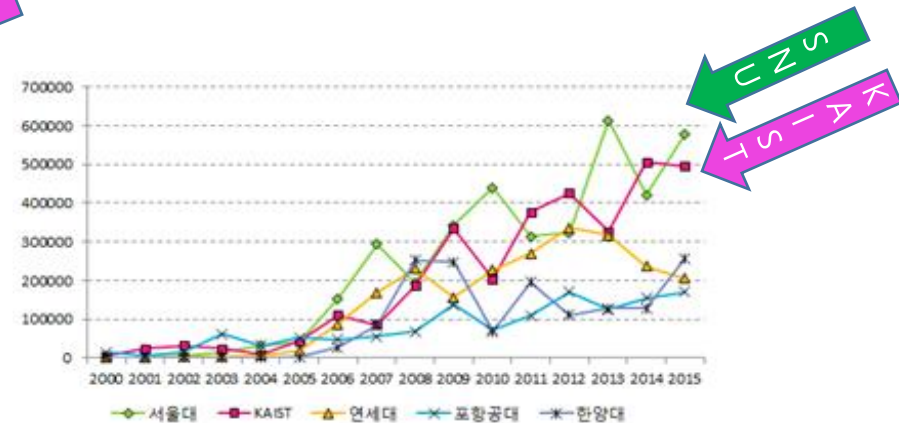
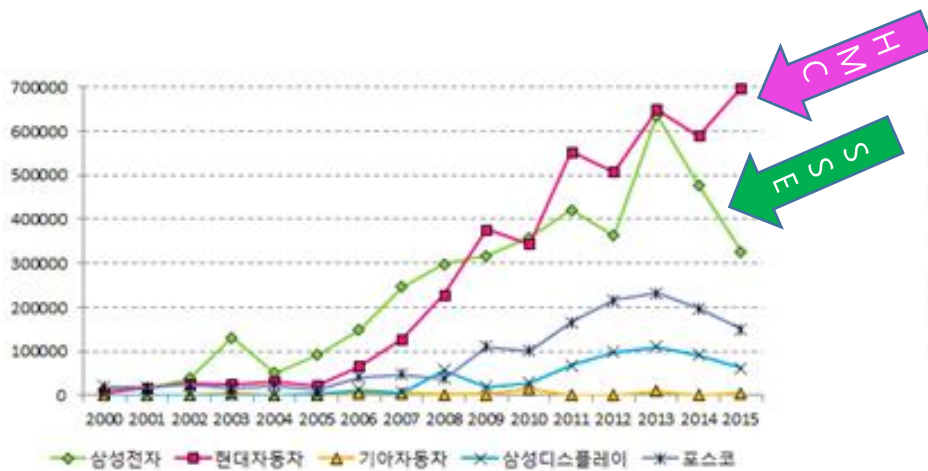
- Seoul-Gyeonggi-Daejeon are three provinces that compose of the core of NW
- Across regional provinces, universities are becoming central
- Research institutes are minor particularly in NW of regional provinces
- Core-periphery structure remains impregnable

- Seoul
- Gyeonggi
- Daejeon
- Other regions



Changes in centrality measures show increases in business groups and universities, while substantial decreases in research institutes

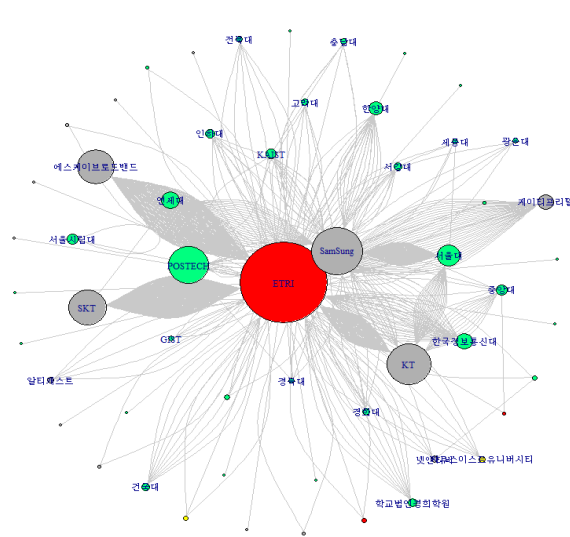
- ✓ Between-ness centrality is shown below; other measures show similar trends
- ✓ This raises a serious question on the role of GRIs in National Innovation System



Note: Because of a data-cleaning issue, post-2015 data are not included; but, the trend continues.

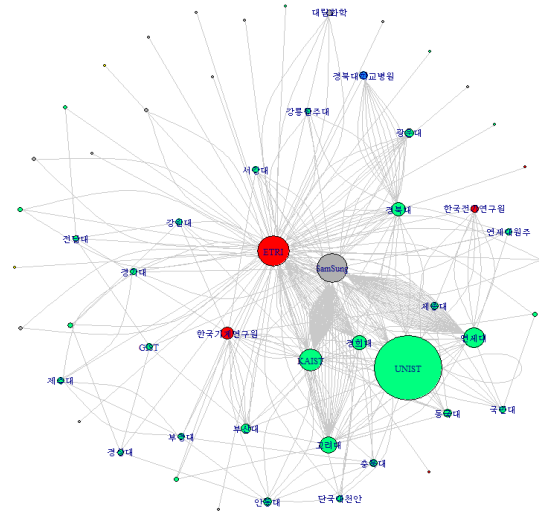
# ETRI

2005



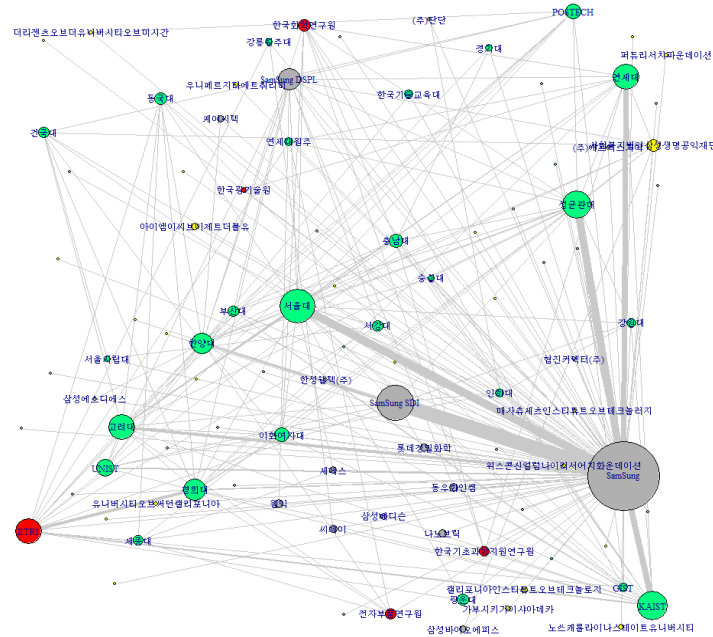
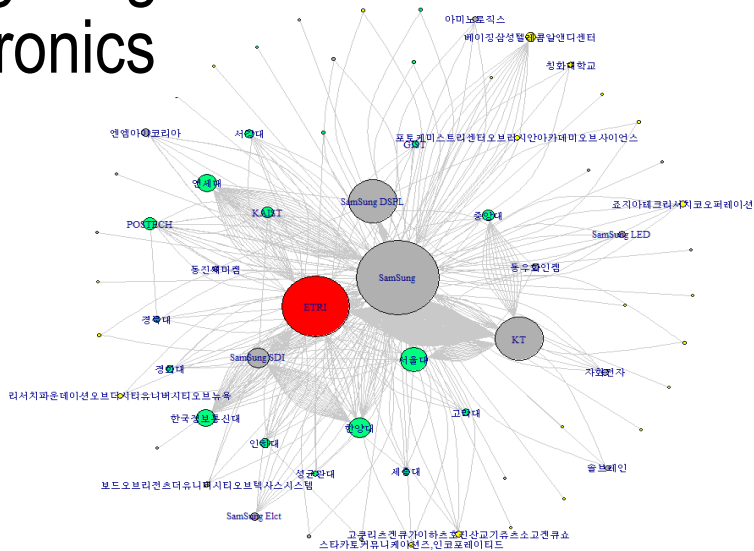
SamSung, 2005

2015



SamSung, 2015

# SamgSung Electronics



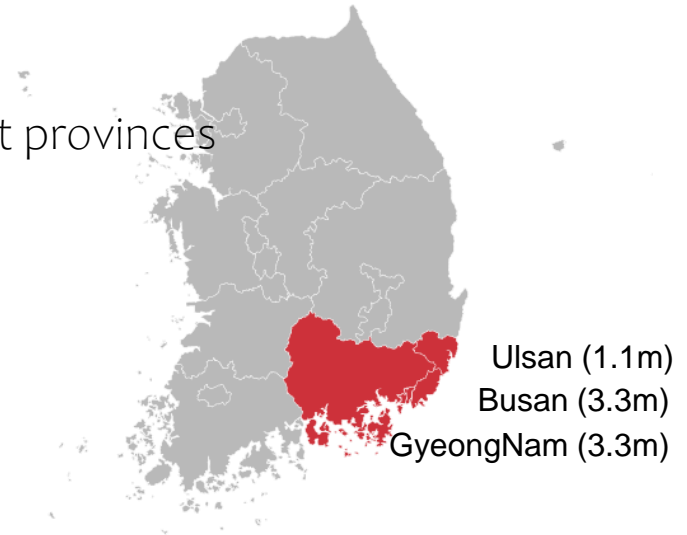
# The emergence of core-periphery structure, if seen from a complex system perspective

		<b>Target</b>																		
		Capital Region				ChungCheng Region			D-G Region			HoNam Region				DongNam Region				Total
		Seoul	GG	Inchen	GW	Daejeon	CB	CN	Sejong	Daegu	GB	Gwangju	CB	CN	Jeju	Busan	GN	Ulsan	Total	
Capital Region	Seoul	18,721	5,728	1,136	273	1,481	519	778	141	526	875	201	296	251	56	452	518	382	32,334	
	Gyeonggi	8,614	19,026	687	331	1,655	360	1,148	68	208	923	249	458	229	56	410	349	339	35,110	
	Incheon	428	606	629	29	78	38	64	10	31	61	9	9	27	7	21	62	177	2,286	
	Gangwon	333	249	41	844	67	49	43	3	6	29	8	34	15	26	6	20	4	1,777	
Chung-Cheong	Daejeon	2,878	2,813	137	68	1,908	216	257	44	91	1,232	120	135	111	30	203	206	118	10,567	
	CungBuk	444	313	32	58	107	964	63	15	18	37	21	34	16	4	44	26	18	2,214	
	ChungNam	308	615	144	50	193	80	1,084	14	31	86	21	78	75	15	39	80	217	3,130	
	Sejong	51	23	3	2	9	18	10	125		7			2		4	22	1	277	
Daegu-Gyeongbuk	Daegu	169	153	8	5	53	11	206	2	686	285	19	23	4	1	32	34	16	1,707	
	GyeongBuk	552	816	81	46	225	77	119	4	294	5,723	16	99	302	10	113	197	94	8,768	
HoNam	Gwangju	132	91	10	2	68	10	22		39	10	482	35	232	1	7	28	11	1,180	
	Jeonbuk	206	415	22	14	86	53	91		42	49	29	1,409	51	4	21	66	11	2,569	
	JeonNam	174	241	29	4	55	7	159	2	9	50	218	85	836	13	136	103	64	2,185	
	Jeju	45	133	5	4	26	1	7	1		2	4	14	7	269	18	9	1	546	
DongNam	Busan	375	230	31	17	109	31	42	8	47	93	16	17	62	11	945	291	49	2,374	
	GyeongNam	359	351	76	44	167	32	84	2	54	106	15	41	80	5	237	1,012	50	2,715	
	Ulsan	172	102	20	12	39	6	59	1	6	79	5	10	16	5	86	47	693	1,358	
Total		33,961	31,905	3,091	1,803	6,326	2,472	4,236	440	2,088	9,647	1,433	2,777	2,316	513	2,774	3,070	2,245	111,097	

S  
O  
U  
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E

## Regions are weak at lateral connection

- Linkage with “core” is stronger than with adjacent provinces
- Core-periphery structures become intensified
- Legacy of “centralization” of powers



	Busan	Ulsan	Gyeong-Nam	Core (Big-3)	Rest
Busan	50	2	8	21	19
Ulsan	4	50	1	37	8
Gyeong-Nam	8	1	35	30	26

**Part 3**

# **Policy Implications**

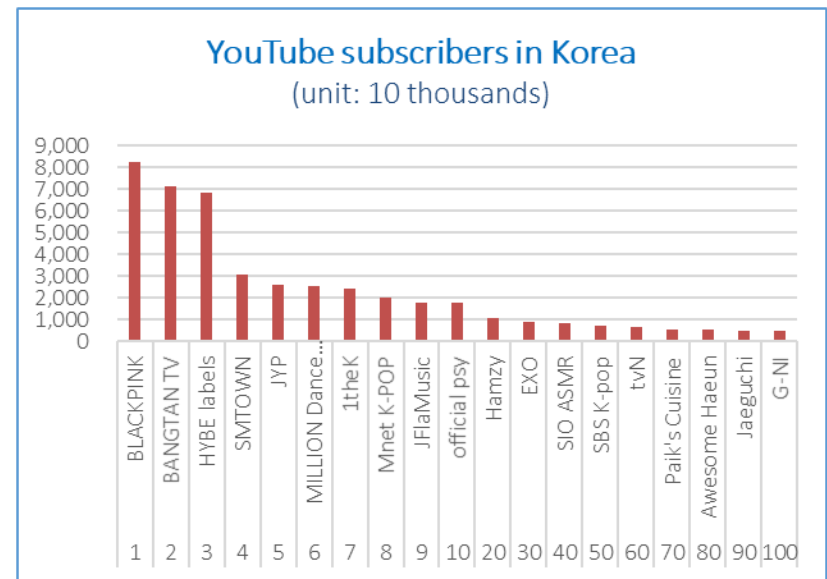
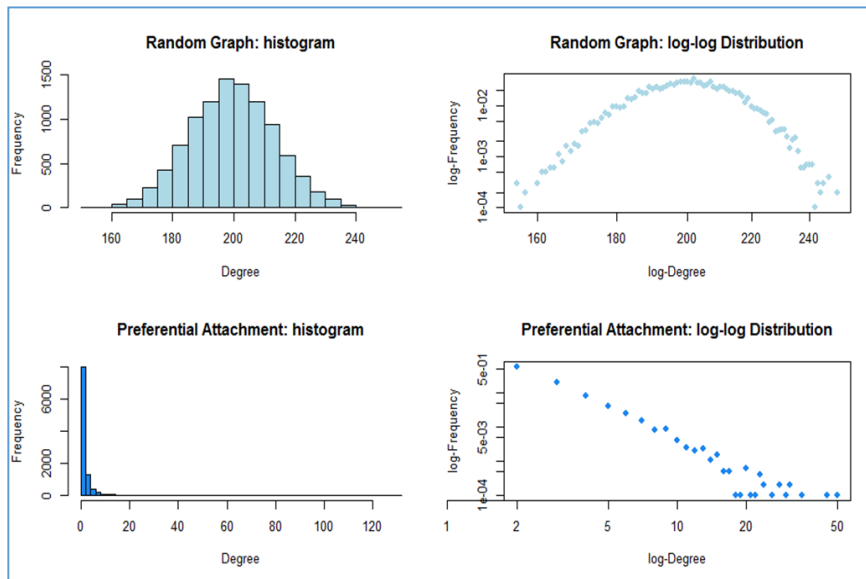
**KPI**

# Transition to an innovation economy

The tendency of preferential attachment becomes stronger in an innovation economy; and the emergence of core-periphery structure is such a case

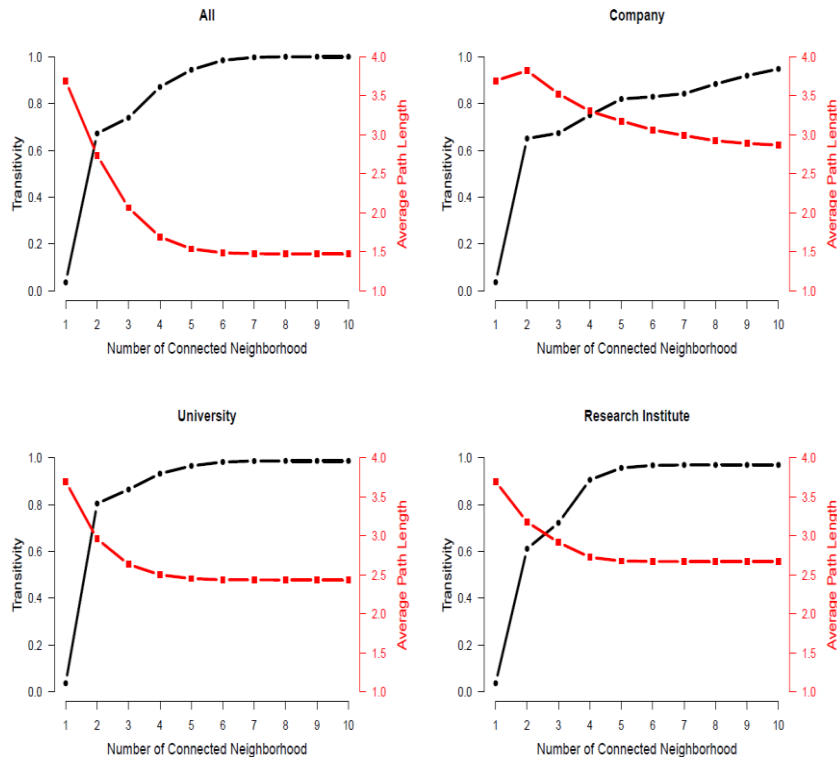
Co-patenting networks conform to these changes in industrial activities. This calls for policy action such as:

- ① Re-defining the role and responsibility of government research institutes, and universities
- ② Enhancing **lateral connections** among actors across regions

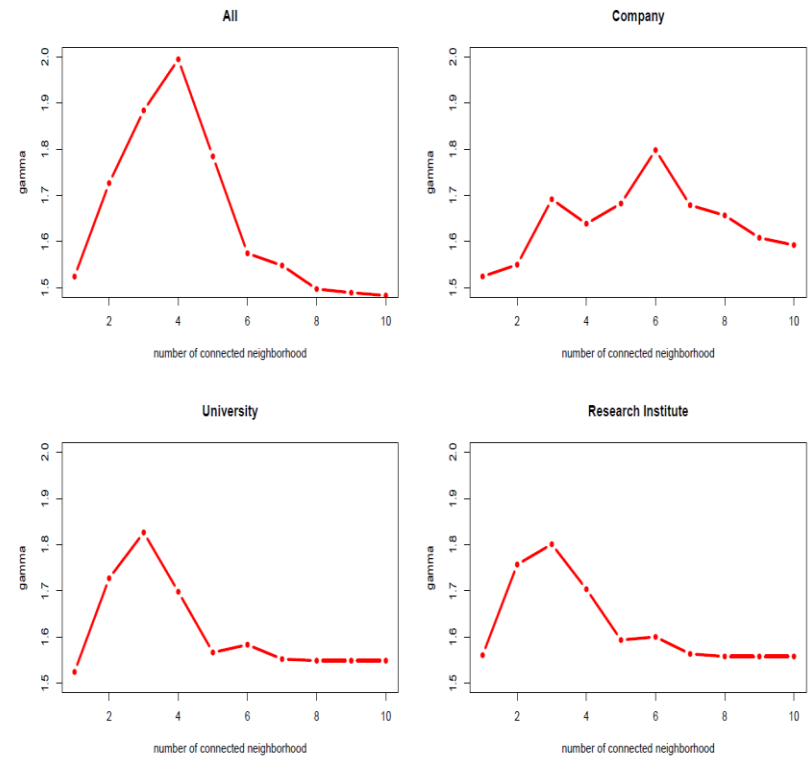


# Random rewiring ( a la Watts-Strogatz, 1998)

## Transitivity & APL



## Gamma





# Near Decomposable Systems

(near-decomposability of complex systems)

- “If we begin with a population of systems of comparable complexity, some of which are ND and some of which are not, the ND systems will, on average, **increase their fitness through evolutionary processes much faster than the remaining system**, and will soon come to dominate the entire population.” (Simon, 1996)
- “If complex systems must operate in a constantly changing environment, or in competition with other systems that are changing, they must **modify their structures at a corresponding pace.**” (Simon, APSA John Gaus Lecture, 2000)

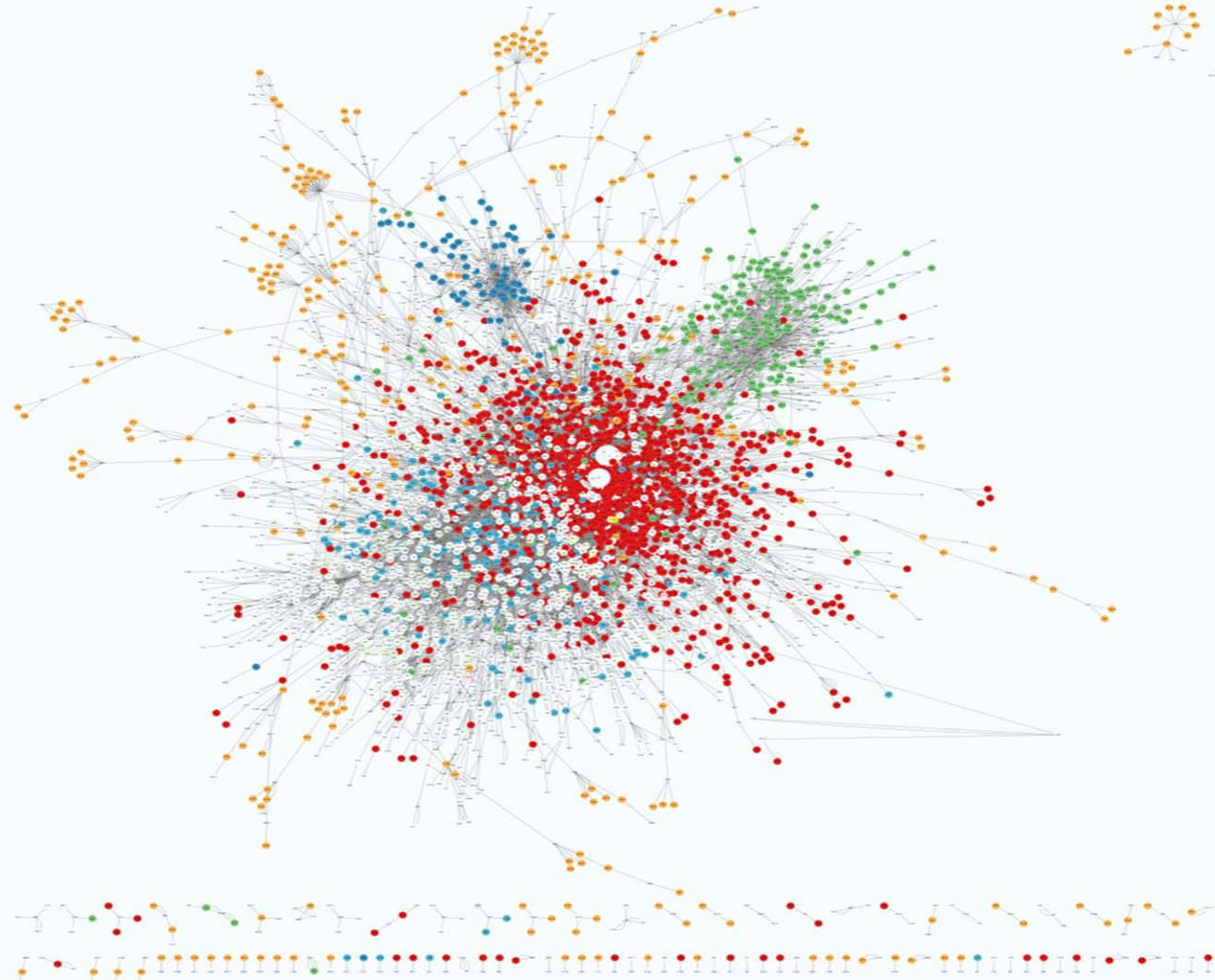


- Herbert Simon (1916-2001)
- 1975 Turing Award: “basic contribution to AI”
- 1978 Nobel Prize in Economics: “pioneering research into the decision-making process within economic organizations”

Appendix | Korea in the Global VC Network



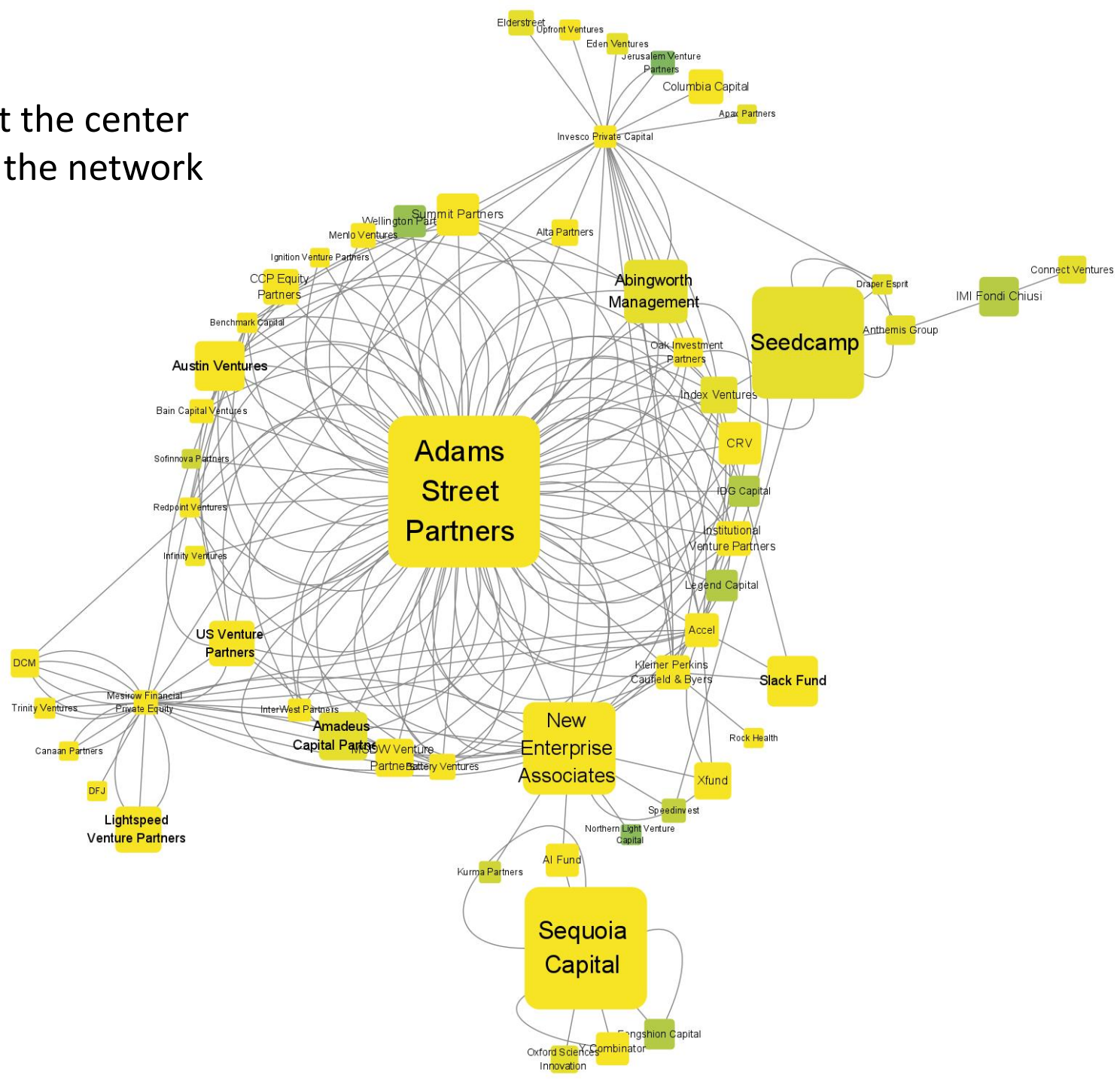
- ❖ Global Venture Capital Networks
- Bipartite NW of Funds
  - ✓ investor-firm network
- As of Jan, 2020
  - 6,425 actors
  - 26,354 funds



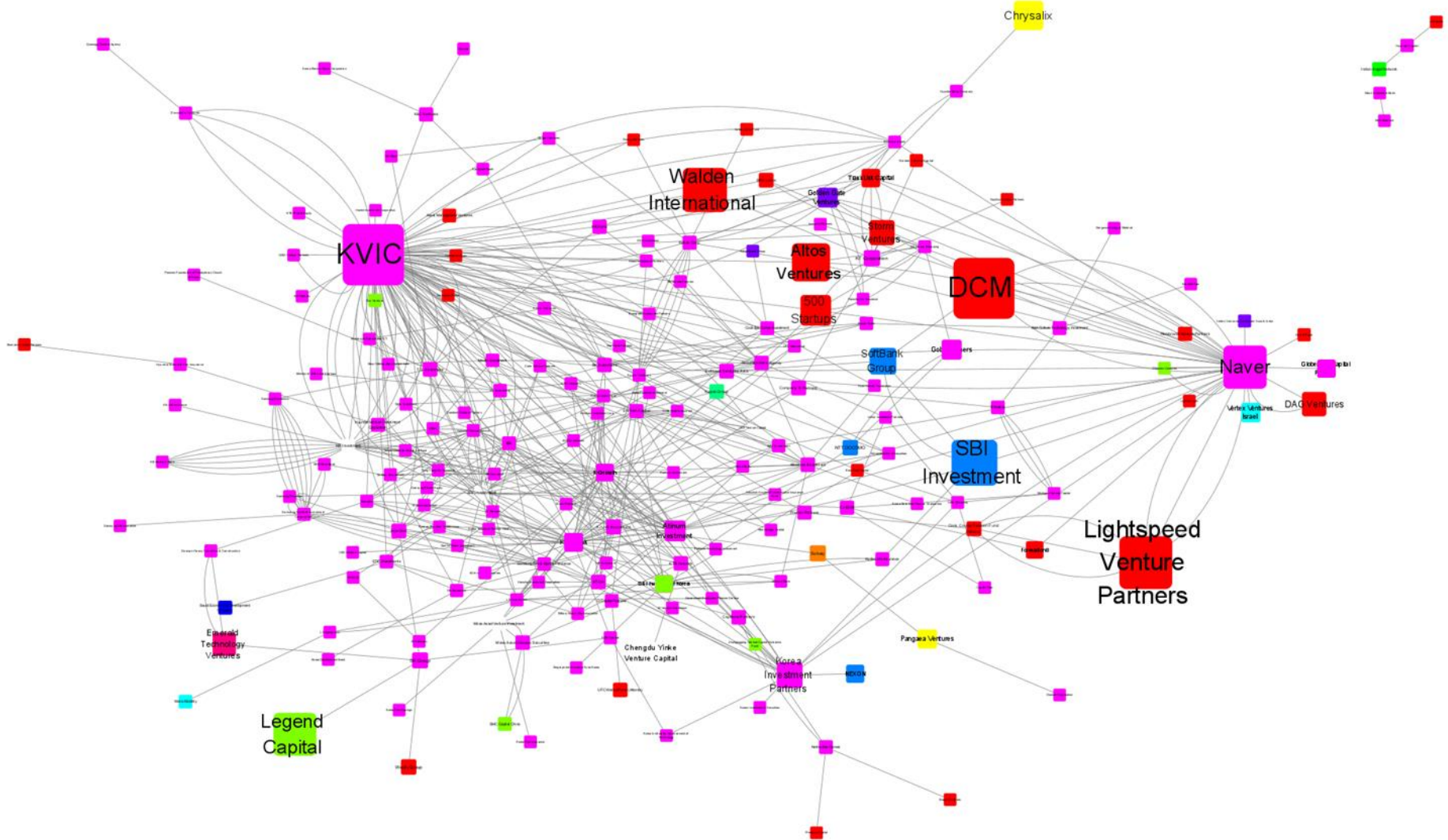
## Investor-Fund Locations (Jan 2020)

Investor Fund	1. US	2. UK	3. China	4. Japan	5. Israel	6. France	7. Canada	8. Korea	9. India	10. DEU	11. Finland	12. AUS	RoW	Sum (World)	(Share, %)
1. US	14,737	418	434	23	245	64	96	2	96	55	4	6	385	16,565	(62.9)
2. UK	576	609	29	2	27	42	4	0	19	21	4	14	124	1,471	(5.6)
3. Japan	122	8	13	794	8	4	12	3	4	1	1	2	23	995	(3.8)
4. China	14	6	883	2	5	1	2	2	0	0	0	0	14	929	(3.5)
5. Canada	170	16	4	2	8	12	319	0	2	4	0	0	22	559	(2.1)
6. Korea	60	0	7	1	2	0	2	438	1	0	0	0	14	525	(2.0)
7. Switzerland	249	116	20	0	19	28	1	0	6	16	6	1	59	521	(2.0)
8. Luxembourg	34	101	0	0	2	62	0	0	0	47	16	4	199	465	(1.8)
9. France	41	42	3	0	14	246	4	0	3	9	0	4	34	400	(1.5)
10. Germany	80	27	16	1	23	11	6	0	6	137	1	1	40	349	(1.3)
11. Finland	31	26	0	0	2	9	1	0	0	2	197	0	50	318	(1.2)
12. Israel	22	3	10	0	232	4	1	0	0	1	0	0	14	287	(1.1)
RoW	638	232	92	14	37	50	26	3	255	33	21	181	1,388	2,970	(11.3)
Sum (World)	16,774	1,604	1,511	839	624	533	474	448	392	326	250	213	2,366	26,354	(100.0)
(Share, %)	(63.6)	(6.1)	(5.7)	(3.2)	(2.4)	(2.0)	(1.8)	(1.7)	(1.5)	(1.2)	(0.9)	(0.8)	(9.0)	(100.0)	

At the center of the network



# Korea





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