How the analysis of structural holes in academic discussions helps in understanding genesis of advanced technology

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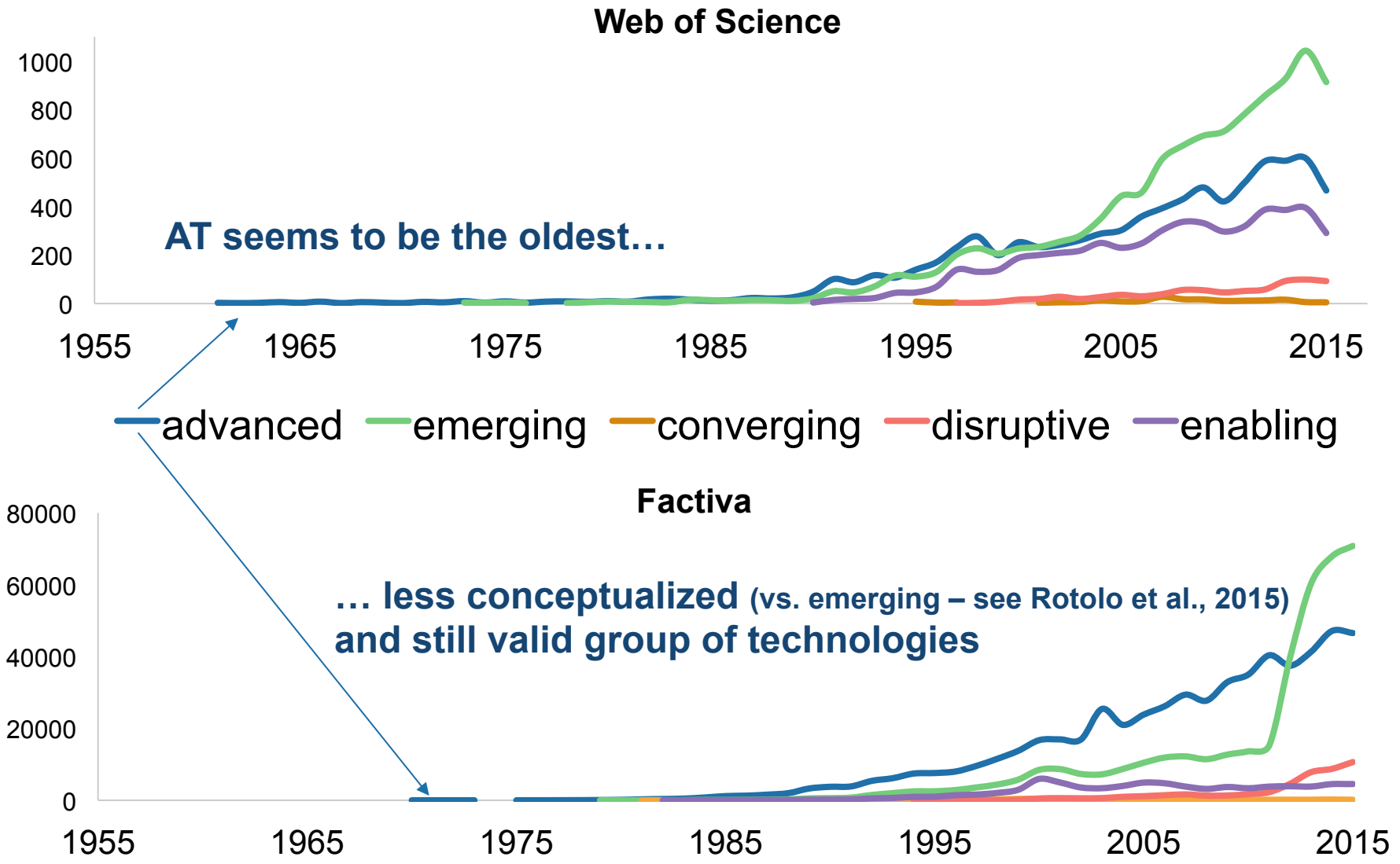
Background

- Continual emergence and dissemination of new technologies
- Importance of certain technology groups for intensive economic growth (next industrial revolution)
- Widespread and increasing interest in developing of statistical indicators explaining evolution and predicting growth of new (emerging) S&T areas
- Lacking conventional definitions and taxonomies for “promising” technology areas against a growing number of umbrella concepts (advanced, emerging, enabling, converging, disruptive, critical and other technologies)

Why advanced technologies (AT)?



Query: TS="advanced technolog*" or TI="advanced NEAR technolog*“ and similar to other categories

Research question

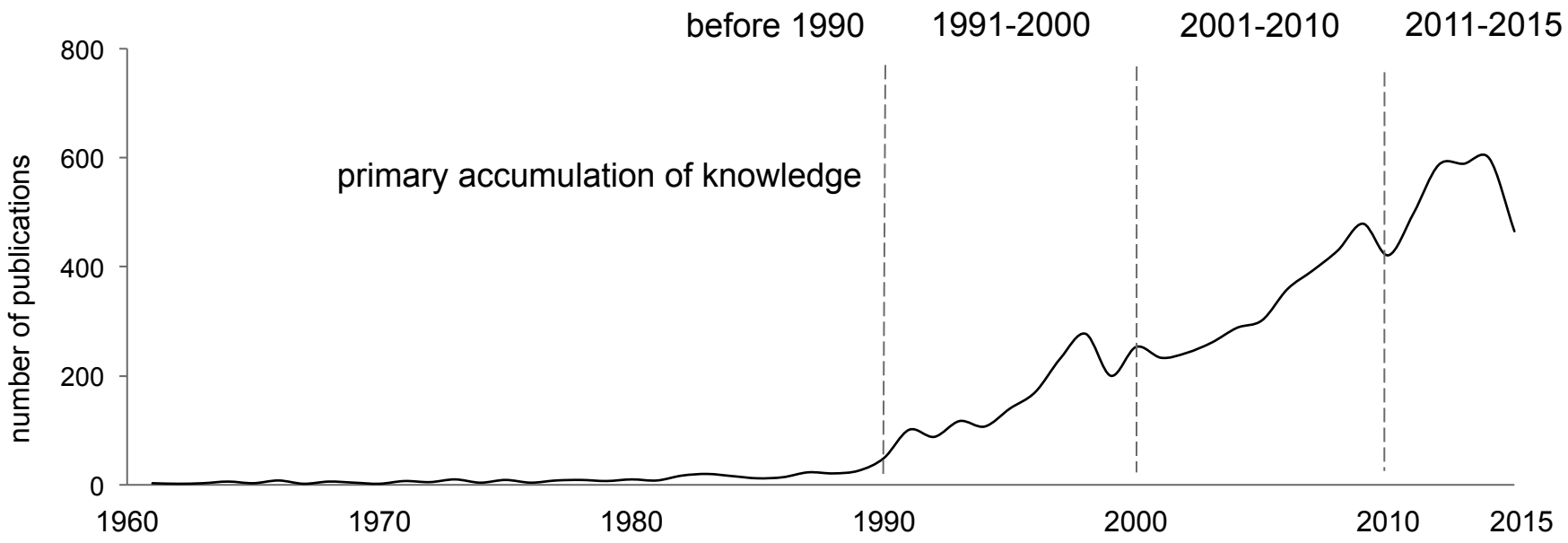
Do studies in AT constitute a separate research field or with the category we have another ‘endless frontier’?

In other words, in professional scientific discourse on advanced technology can we identify a communication core that set up conceptual framework and/or research agenda for a certain period?

Methodology

0. *Identification of* relevant academic *papers* in the corps of professional literature
1. Analysis of *publication dynamics* in order to identify relevant periods of sustainable growth for in-depth exploration
2. *Keyword analysis* to highlight main research topics in each of the periods
3. *Co-citation analysis* to single out networks that had set up research agenda for each of the periods
   - as invisible colleges (Gmür, 1973) or clusters of science (Small, 1999)
   - as sources of inspiration for emerging topics (Small et al., 2014)
   - as 'knowledge base' of certain fields (Fagerberg & Verspagen, 2009; Fagerberg et al., 2012)
4. Application of *betweenness centrality* to identify core elements of the networks
   - optimally positioned actors that can accumulate information flows from dislocated parts of a network (Bavelas, 1948, 1950)
   - structural holes that provide opportunities for mediating knowledge flows in a wider community of actors (Burt, 2002)
5. *Comparing betweenness centrality* of papers cited in two consecutive periods with papers cited in one period only

1 Publication dynamics



Query TS="advanced technolog*" or TI="advanced NEAR technolog*".

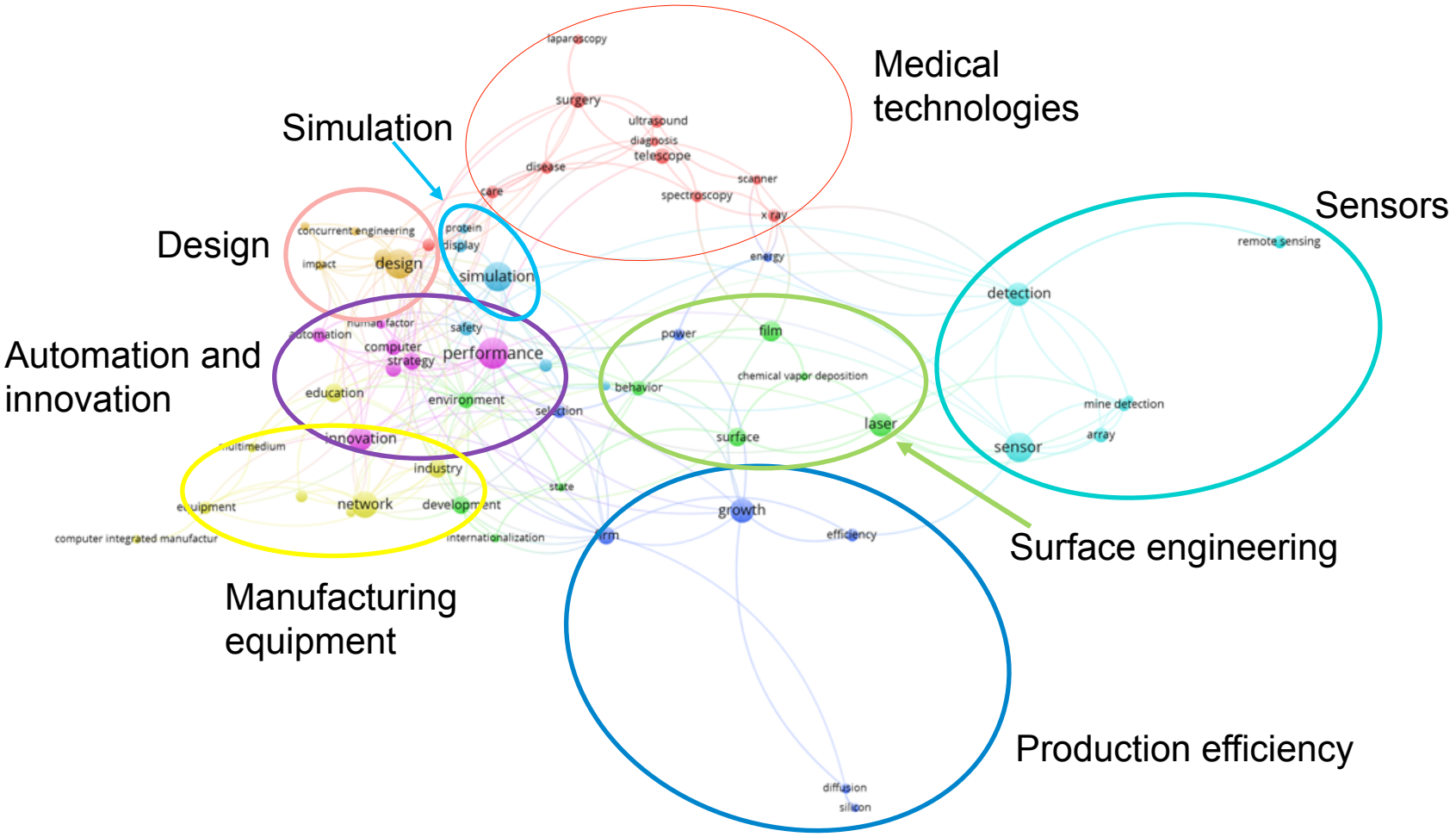
Source: WoS Core Collection (all types of publications in all indices)

2 Keyword analysis before 1990: homogeneity of discussions

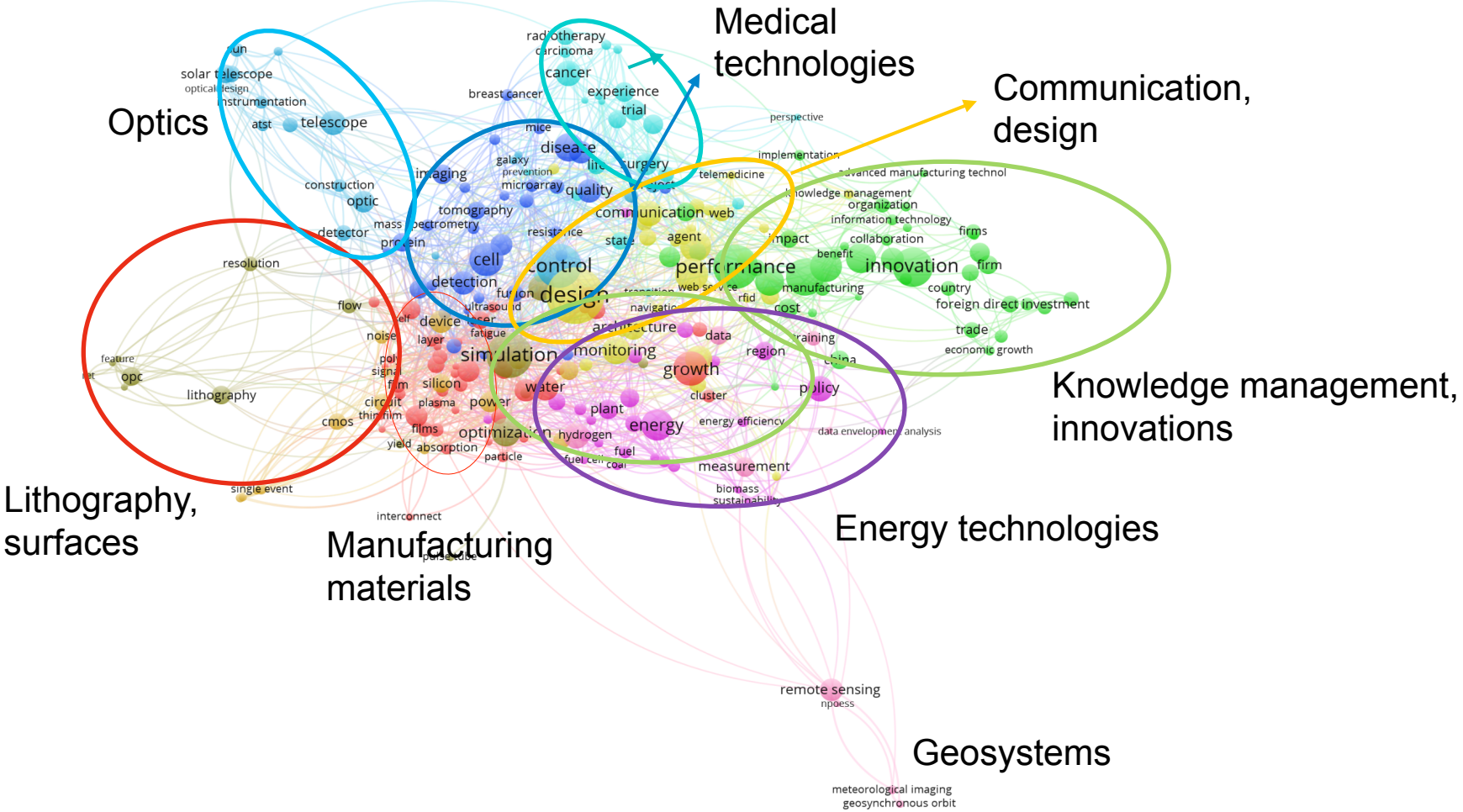
Top 5 domains
1. Engineering
2. Business/economics
3. Other topics of science and technology
4. Material science
5. Optics

Key issues: role of technologies in economic development
engineering education and skills
human resource management

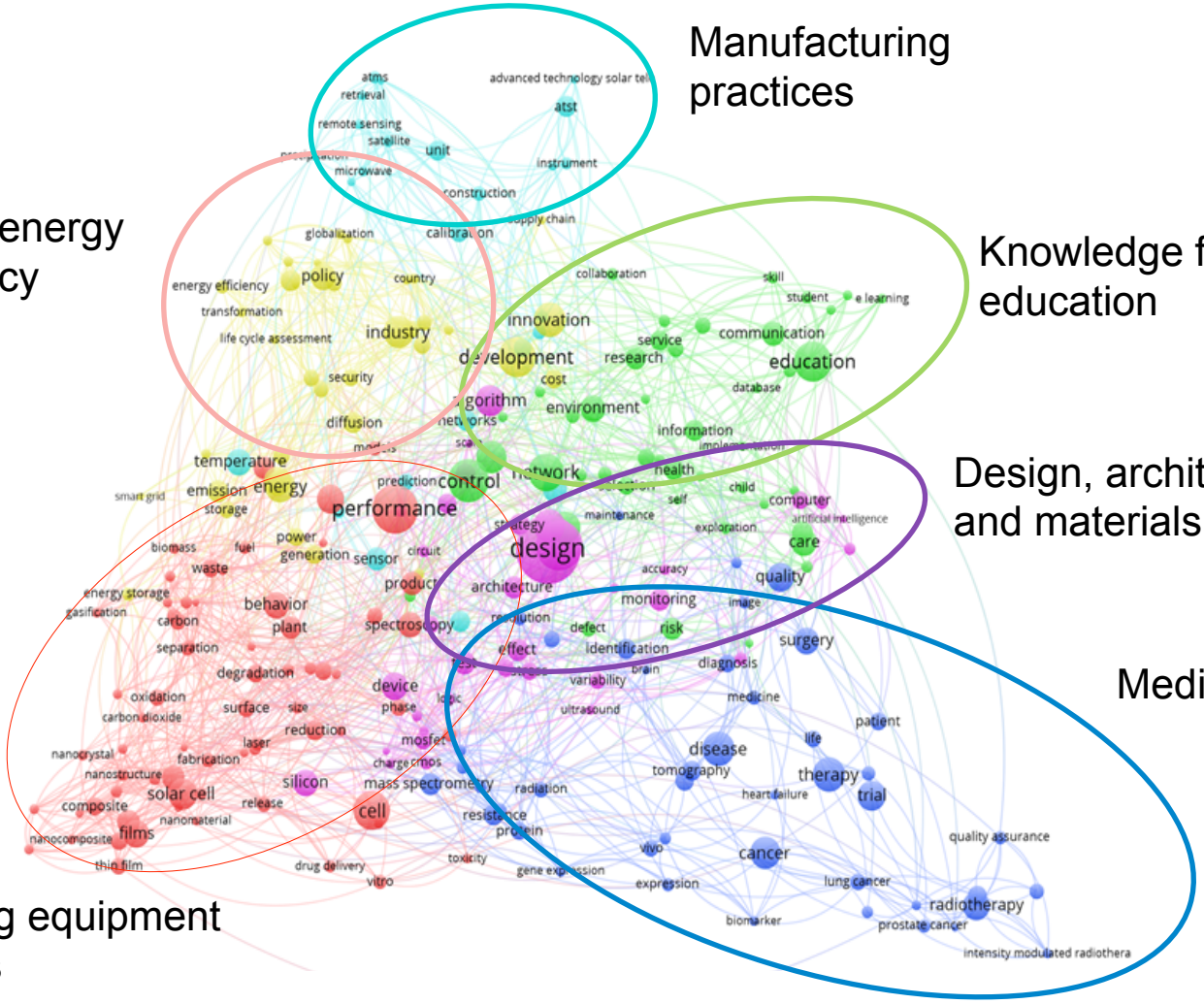
2 Keyword analysis 1991-2000: primary specialization (manufacturing)



2 Keyword analysis 2001-2010: AT beyond manufacturing

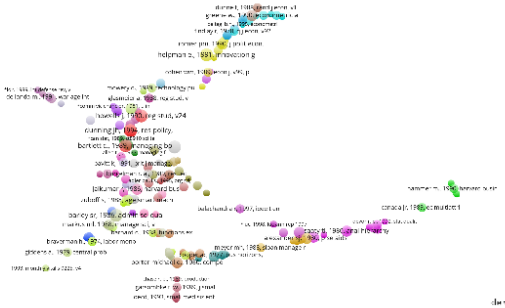
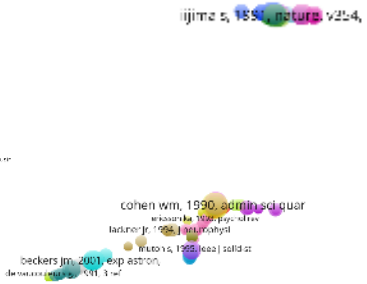
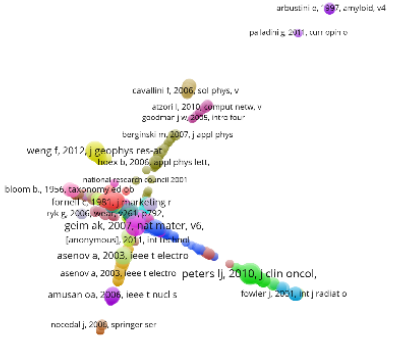


2 Keyword analysis 2011-2015: focus on implementation & management



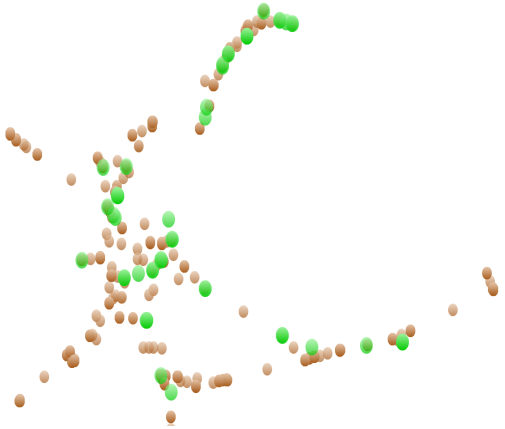
3 Co-citation networks: key parameters

Selected for further analysis

before 1990	*1991-2000*	*2001-2010*	*2011-2015*
			
N = 1268 *Threshold* = 1 *Connected nodes* = 128	*N = 18827* *Threshold = 1* *Connected nodes = 2606*	*N = 66533* *Threshold = 2* *Connected nodes = 1658*	*N = 79484* *Threshold = 2* *Connected nodes = 2376*
Key issues: role of AT in changing social and economic structure	***Key issues*:** technology and innovation management	***Key issues**:* management of tech, innovation, globalization	***Key issues**:* technology domination

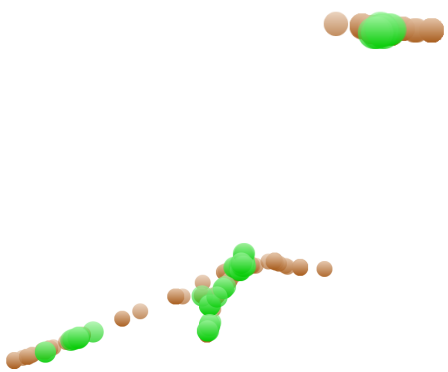
4 Identification of structural holes

1991-2000



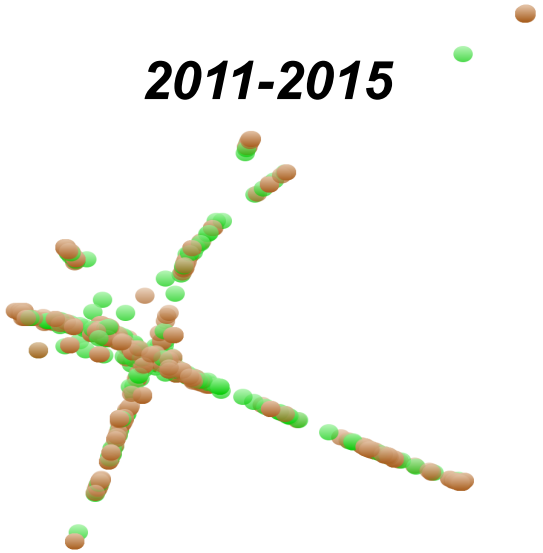
Moving to the next period = 85
Share of total = 3.3%

2001-2010



Moving to the next period = 118
Share of total = 7.1%

2011-2015



***Potentially** moving* = 358
Share of total = 15.1%

		1	2	3	4	5
	Period	1960-1990	1991-2000	2001-2010	2011-2015	2016-…
1	1960-1990	-	0			
2	1991 – 2000		-	85	26	10
3	2001 – 2010			-	118	42
4	2011-2015				-	358

Period	**Mean betweenness of authors who move**	**Mean betweenness of authors who don't move**	**Wilcoxon statistics**	**p value**
1991 – 2000	31822.6	3124.6	18827	< 0.01
2001 – 2010	17883.2	5986.6	3050	< 0.01

5 Identifying key technology driven areas from papers with higher betwenness centrality

1991-2000

- Global technology markets and emergence of new form of firms – multinational; Foreign investments and their spillover effects; Measuring productive efficiency; Innovation development; Technological change

2001-2010

- All previous + Biotechnology, Nanotechnology, Oncology, Semiconductors, Mathematical modeling, Astronomy (Advanced Technology Solar Telescope), Microelectronics, Environment, Medicine

2011-2015 (topics likely to emerge in the further decade)

- Environment; Energy; Fuels; CMOS Transistors; Electrical Engineering; Genetics; Geochemistry; Material Sciences; Meteorology; Oncology; Technology and Society

Discussion and conclusions

- There is observable penetration of the concept on ‘Advanced Technology’ from social sciences discourse to natural and engineering disciplines identified both through the analysis of co-citation networks and keywords mapping:

  from R&D and technology management (1991 – 2000) to innovation studies (2001 – 2010) and discussions on specific technologies (2011 – 2015)

- Co-citation networks eliminated a common background for the papers in the observable periods and therefore can be considered as a ‘knowledge base’ of the professional discussions, however, different traditions in citations might lead to systemic bias towards certain disciplines
- Application of centrality metrics allowed identification of key works of the period and empirically verify the adoption of the ‘politically sounding’ term by specific studies in technology
- No stable communication core was identified – there is still continuous diversification of the topics associated with the concept of advanced technology
- Further work can be aimed at deeper analysis of the disciplinary structures in communication networks and identification of specific technologies considered as advanced in certain time periods

Thank you!

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