Halle Institute
for Economic Research

The structure and evolution of inter-sector resource complementarity in R&D in Germany from 1990 to 2010

Tom Broekel* and Matthias Brachert#

* Leibniz University Hanover
# Halle Institute for Economic Research

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Outline

- Resource complementarity
- Empirical approach and data
- A complementarity space for Germany (static and dynamic)
- Conclusion

Resource complementarity

Resource complementarity (I)

- Collaboration essential for organizations' economic performance

  (Powell at al., 1996)
- Collaboration particularly beneficial in R&D
  - Sharing of risk, collective learning, **pooling of resources**

    (Teece, 1986; Inkpen & Tsang, 2007)
- Successful collaboration is not automatically given
  - Trust, commitment, collaboration management, **fit between partners, partner selection**

    (Cohen & Levinthal, 1990, Wassmer & Dussauge, 2011)

What are "*best*" partners and what does fit mean?

Resource complementarity (II)

- Multiple concepts and arguments in literature
  (Powell et al., 1996, Eisenhart & Schoonhoven, 1996, Frenken et al., 2007)
  - Collaboration should give access to
    - Supplementary resources (Symmetry of partner resources, allow cost sharing and benefits from economies of scale, low potential for radical innovations)
    - Complementary resources (Substantial differences in partner resources, cognitive distance; benefits arise from (external) economies of scope, fit of resources allows creation of novelty with potential for more radical innovations, not just dyadic but subject to portfolio)

Resource complementarity (III)

- Resource relatedness
  - Focus on optimal cognitive distance between partners
  - Relatedness allows benefits from (still) easy communication while differences in the knowledge resources of partners are present
  - Source of benefits – Interplay of economies of scale and scope
- Framing these three concepts
  - Supplementary and complementary resource as necessary conditions for successful collaborations
  - Related resources are sufficient condition of successful collaborations

Focus – Resource complementarity

- **Which industries offer complementary resources to other industries?**
- **How does the complementarity space for Germany looks like?**
- **Does the complementarity space for Germany changes over time?**

Study has descriptive character - follow up applications in progress

Empirical approach & data

Empirical approach & data (I)

- Main idea
  - No random or completely non-rational selection of collaboration partners
  - Partner selection to maximize (perceived) benefits for successful R&D
  - Many collaboration attempted - surviving collaboration are good proxy

    (Stigler, 1968; D'Este et al., 2012)
- Central assumption
  - **Observed cooperation patterns = positively evaluated combinations of resources, skills, and knowledge (maximal benefits = complementarity of resources)**
  - Collaboration intensities between sectors indicate degree of resource complementarity

Empirical approach & data (II)

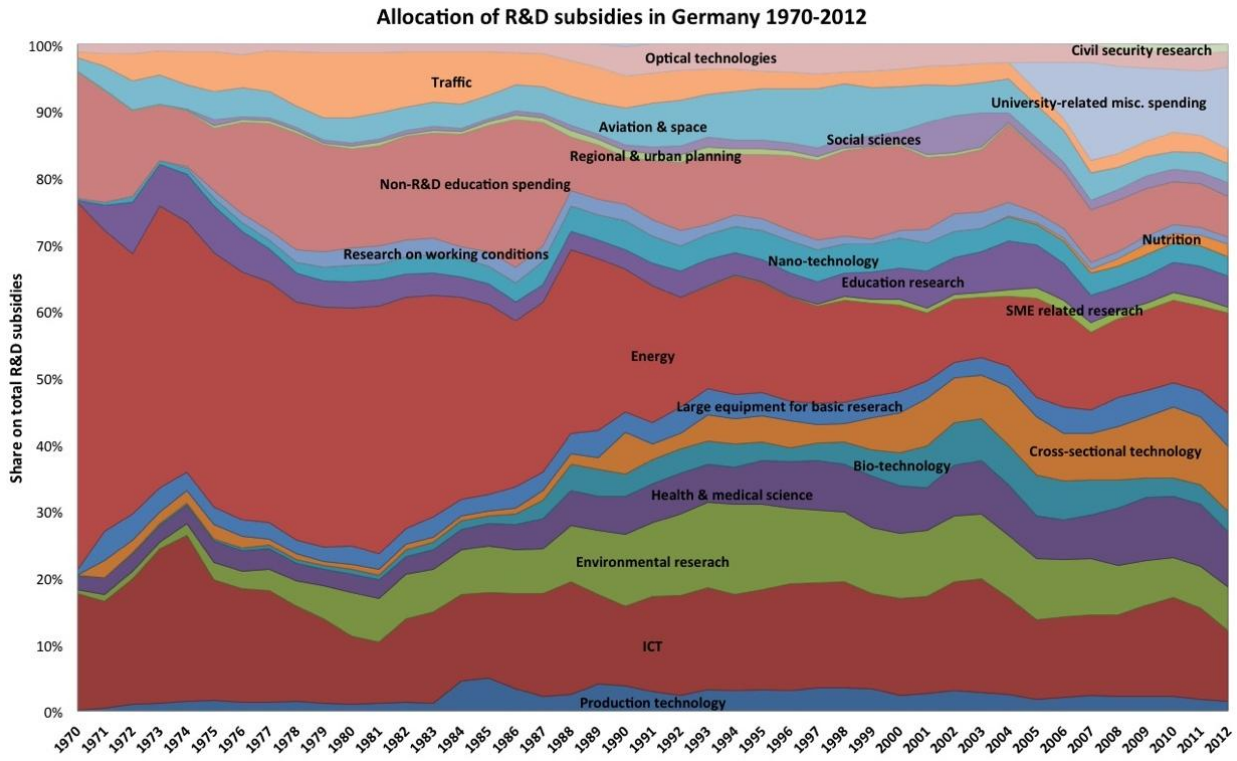
- Data on R&D collaboration
  - Information on joint R&D projects subsidized by German Federal Government (BMBF, BMWi,..), *"Förderkatalog"*
  - Years 1990 to 2010:
    - 62,714 projects (including individual projects)
    - 103,411 individual funds
    - 30,116 German organizations
  - Information on starting & ending data, fund size, NACE code, technological classification *("Leistungsplansystematik"*), type of organization

Empirical approach & data (III)

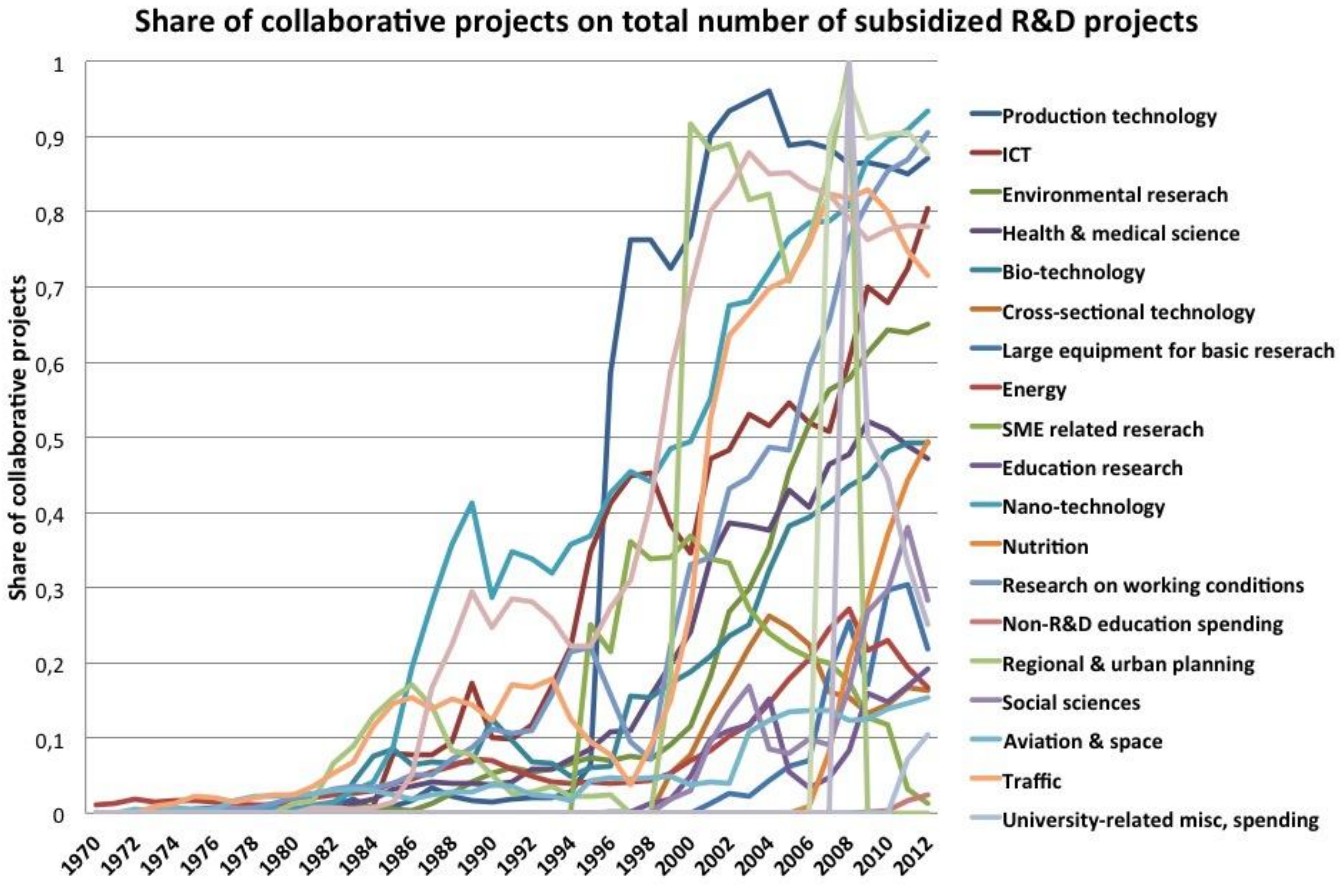
- Definition of industries as in Frenken et al. (2007), Hartog et al. (2012)
  - Resource complementarity between different 2-digit sectors
  - Some special cases, f.e. universities and R&D sectors, here 3-digit level
  - 93 industries, including the service and the public sector
  - Update - deeper differentiation of universities into 12 disciplines
  - However - this is only partially integrated into the results

Empirical approach & data (IV)

- Focus on 93 2- and 3-digit NACE sectors (some sectors too heterogeneous at 2-digit level)



Empirical approach & data (V)



Empirical approach & data (VI)

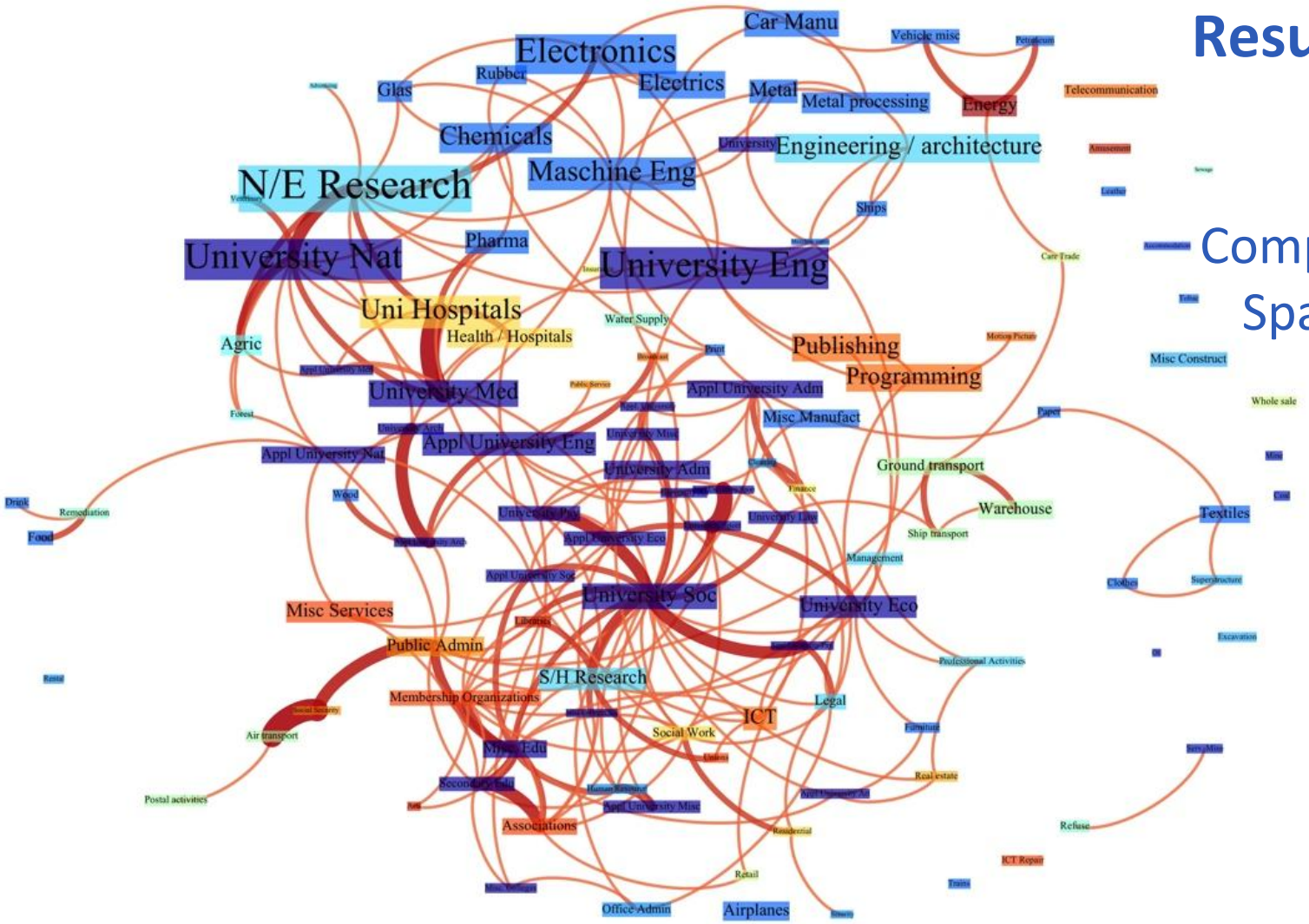
- Indicator of inter-sector resource complementarity
  - **Co-occurrence indicator** *(Teece et al, 1996; Bryce & Winter, 2009)*
  - **Compare observed co-occurrences of sectors in joint projects with what can be expected by random distribution** (consideration of sector size)
    - Sector size approximated by number of collaborative R&D projects organizations participate in
    - Complementarity index weighted with relative contribution of sector in joint projects (share of fund)
    - No consideration of indirect relation between sectors
    - Negative values treated as zero complementarity
  - Application of **social network analysis** to explore structure of complementarity space & position of sectors

Results

Results (I)

- Robustness
  - Few “surprisingly” strong complementarity relations (e.g. social security and air transport)
  - Strongly subsidized sectors more central, however:
    - Small correlation between two sectors’ intensity of subsidization and the their dyadic complementarity (R>0.35)
    - **Sectors gain centrality through their resources being complementary to other sectors!**
  - Small changes between years (Structure, degree of complementarity, central sectors)

Results (III)



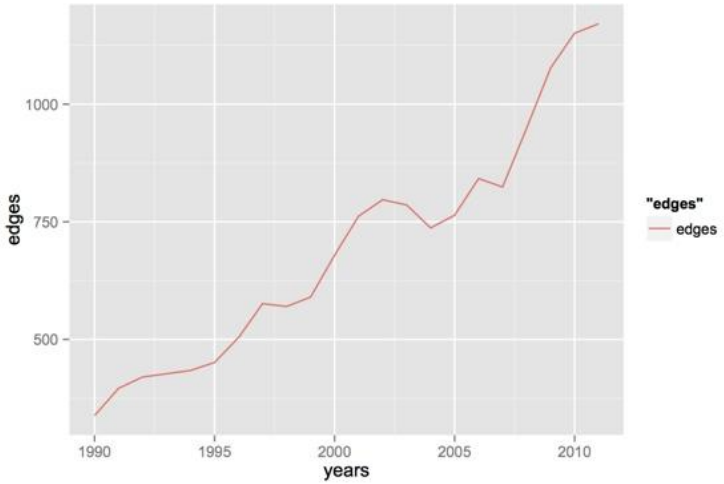
Complementarity Space in 2010

Results (IV)

- Main results (resource complementarity in 2010)
  - Higher education (*universities, appl. Universities, here especially the engineering departments*) and research sectors (*N&E, S&H*) **central** (degree)
  - Specific sectors **connect** distant areas of complementarity space (*programming, universities, misc. vehicles, engineering & architecture*)
  - Non-manufacturing sectors frequently **bridge (complementarity) gaps** between manufacturing sectors (closeness centrality)
  - Existence of complementarity **cliques** (e.g., ground transport, warehouse, and ship transport; pharma, health, university hospitals and N&E research)

Dynamic Perspective

Results (V)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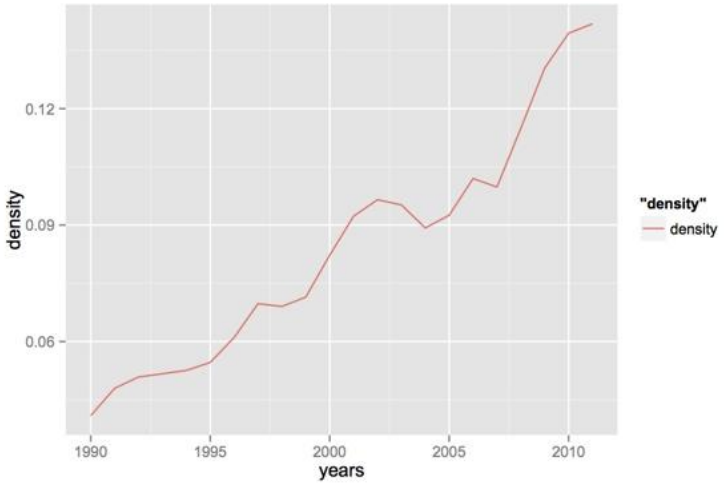
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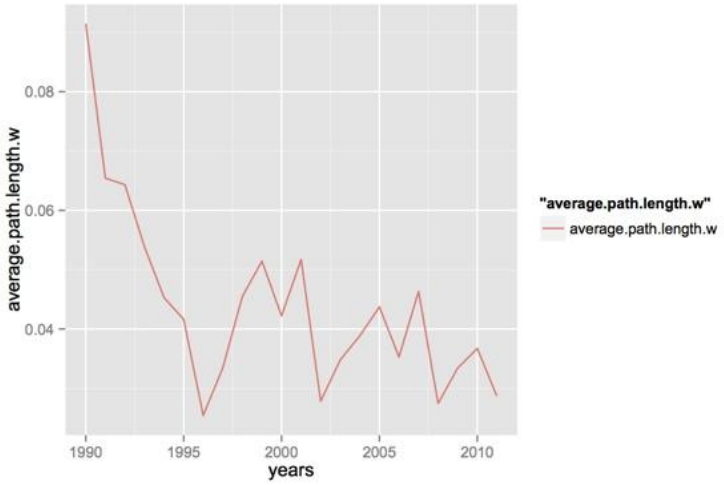
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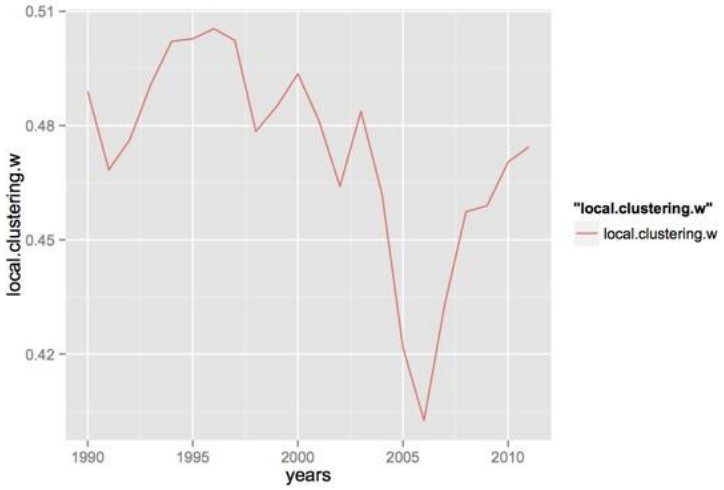
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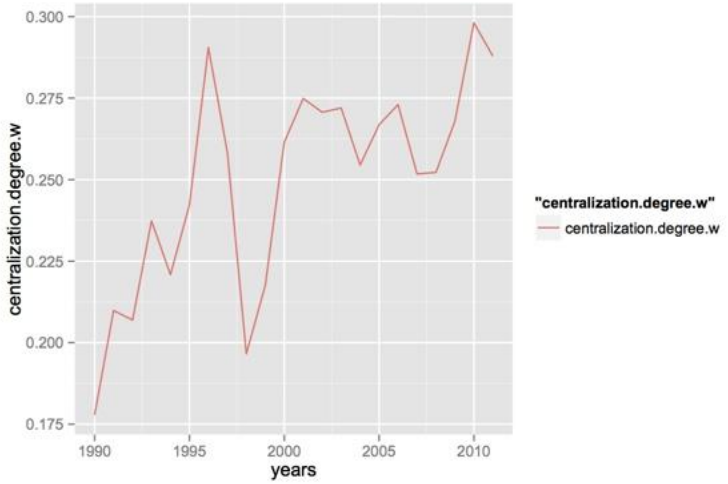
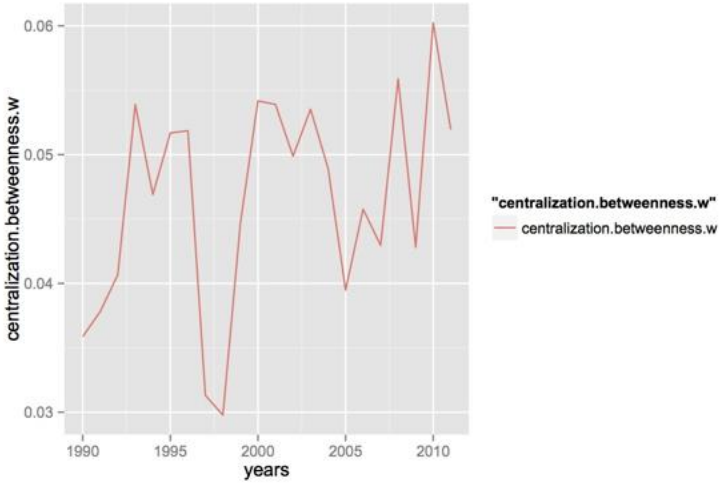
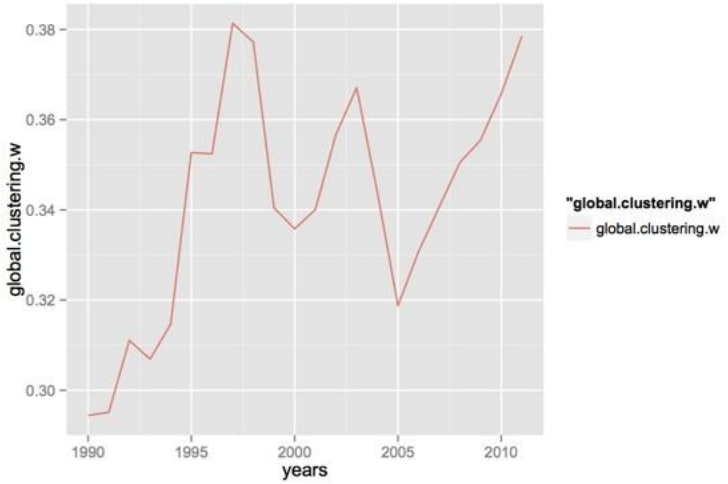
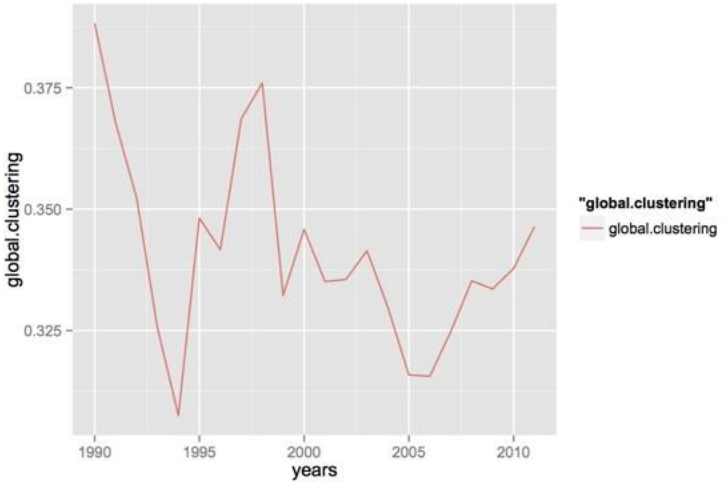
Results (V)









Results (VI)

- Complementarity space **evolves**
  - Higher education and research gained in degree centrality
  - ICT, environmental technologies, arts and social science gain in closeness centrality sectors
  - Overall density increased
    - **Deepening pattern**: cliques of strong complementarity integrated further while less integrated cliques dissolved
    - **Widening process**: more sectors connected to core of complementarity space (core's resources became more universally combinable)

Conclusions

- The **good**
  - Data well-fitting for investigation: evaluation process of granting strengthens survivor principle
  - Empirical results make sense & include none-manufacturing sectors
- The **bad**
  - Political bias in data, subsidization preferences for certain technologies?
  - Heterogeneous definition of sectors
- The **imperative**
  - More research needed
  - Comparison with other approaches / data

Thank you for your attention!