NEW MODES AND DEVELOPMENTS OF SCIENCE-INDUSTRY INTERACTION IN GERMANY

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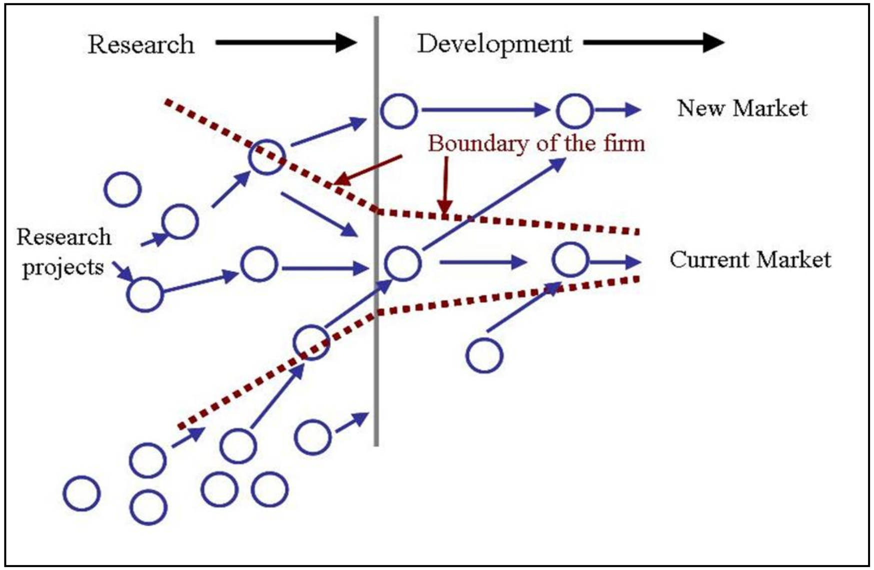
Open innovation approach

- The complexity of technology development and innovation processes increases. Strategy: **collective technological and financial risk minimization.**
- The **opening of the innovation process** is based on two directions (Gassmann/ Enkel 2006)
  - Inbound: Use of external knowledge in the enterprise
  - Outbound: Supply of knowledge created in the enterprise
- By integrating customers, users, heterogeneous external experts in all phases of the innovation process: obtaining information needs and contribution to the search for a solution; interactive value creation (Reichwald/Piller 2009).
- Thematization of substitution effects by external research and capacity building in the topics of the partners in order to develop and to integrate ideas together (Dahlander/Gann 2010) .



Source: Chesbrough 2006

Coordination of science-industry linkages

- From a theoretical point of view, strategic research partnerships can, among others, be explained by the **transaction costs approach** (Williamson 2002).
- This approach examines the circumstances under which are cooperation agreements are most efficient form of organization, i.e. **transaction cost efficiency** is seen as a motivation for such cooperation.
- The formation of network and partnership structure is a **form of coordination** that enables flexible access to external resources and a suitable tool for companies is to save internal resources (Hunt/Morgen 2000, Aldrich/Zimmer 1986, Becker/Dietz 2004).
- With regard to knowledge and innovation, **external acquisition can increase the coordination effort**. Furthermore, internal knowledge and skills must be available to use external knowledge (**absorptive capacity**) (Cohen/Levinthal 1990, Lichtenthaler 2009).
- Furthermore, networks and partnerships can lead to rigid relations and can become encrusted => flexible relationships with various partners and openness to new partners are important (**"weakness of strong ties"**) (Granovetter 1973 and 1985, Grabher 1993).

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Motives for strategic research partnerships from the viewpoint of companies

- Increasing international competition and technological complexity lead to shorter product and technology life cycles and thus to an increasing **importance of strategic research partnerships.**

- **Motives** for strategic research partnerships from the perspective of industry:
  - Access to new technologies and the know-how of the partner
  - Securing competitiveness
  - time benefits
  - cost reduction
  - risk diversification
  - synergy effects
  - contact with potential employees

- Strategic research partnerships can also be influenced by **political measures** if these are effectively directed on the R&D cooperation between science and industry.

Sources: Coombs et al. 1996, Hagedoorn 2002, Archibugi/Coco 2004, Becker/Dietz 2004

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Challenges and barriers of research partnerships

- **Fear of loss of strategically important knowledge** can prevent or reduce exposure to research partnerships.
- In order to use knowledge from outside, knowledge and skills must be available in the company (**absorptive capacity**). Often, small companies are at a disadvantage here.
- Small firms are due to their resource endowments at a disadvantage when it comes to the **financing of R&D and innovation activities.**
- Transaction costs may be reduced internally, but rise externally. In addition to the management of the innovation process itself, the **management of the research partnership** is a challenge.
- Too close connections to the partners can lead to lock-in situations. Flexibility and openness to new partnerships should be aspired.
- Networks can be characterized by asymmetries of power.

Sources: Bapuji et al. 2011, Caloghirou et al. 2004, Escribano et al. 2009, d'Este et al. 2012, van de Vrande et al. 2009, Du et al. 2014

Knowledge and technology transfer - Basic definitions

- **Knowledge** includes facts, the code for the interpretation of information, explicit theories, cognitive and intuitive elements. Knowledge is specific to the user. Knowledge can be **explicit** when it is codified and documented in publications, blue prints, databases and incorporated in machines, devices and processes. It is **implicit (or tacit)**, i.e. not codified and documented (Polanyi 1966), when it is incorporated in persons or procedures (Nonaka 1994) and when it can only be transmitted through personal contacts and verbal / non-verbal communication.

- **Technology** can be defined as (according to Webster 1989):
  1. The science or study of the practical industrial arts;
  2. The terms used in a science, technical terminology;
  3. Applied science.

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Technology and knowledge transfer

Different definitions:

- Technology transfer is the movement of know-how, technical knowledge, or technology from one organizational setting to another (Roesner in Bozeman 2000)
- Knowledge transfer is the process through which one unit (e.g., group, firm, region, nation) is affected by the experience of another (Argote/Ingram 2000).
- Technology and knowledge transfer is the process of sharing skills, knowledge, technologies, methods of manufacturing, samples of manufacturing and facilities among governments and other institutions to ensure that scientific and technological developments are accessible to a wider range of users who can then further develop and exploit the technology into new products, processes, applications, materials or services (different authors).

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Technology and knowledge transfer

The definition of technology transfer differs substantially between disciplines:

- Economists (Arrow 1969; Johnson 1970; Dosi, 1988) tend to define technology transfer on the basis of the properties of generic knowledge, focusing particularly on variables that relate to production and design.
- Sociologists (Rogers 1962; Rogers/Shoemaker1971) tend to link technology transfer to innovation and to view technology, including social technology, as "a design for instrumental action that reduces the uncertainty of cause–effect relationships involved in achieving a desired outcome".
- Anthropologists (Foster 1962; Service 1971; Merrill 1972) tend to view technology transfer broadly within the context of cultural change and the ways in which technology affects change.

(according to Bozeman 2000, p. 630)

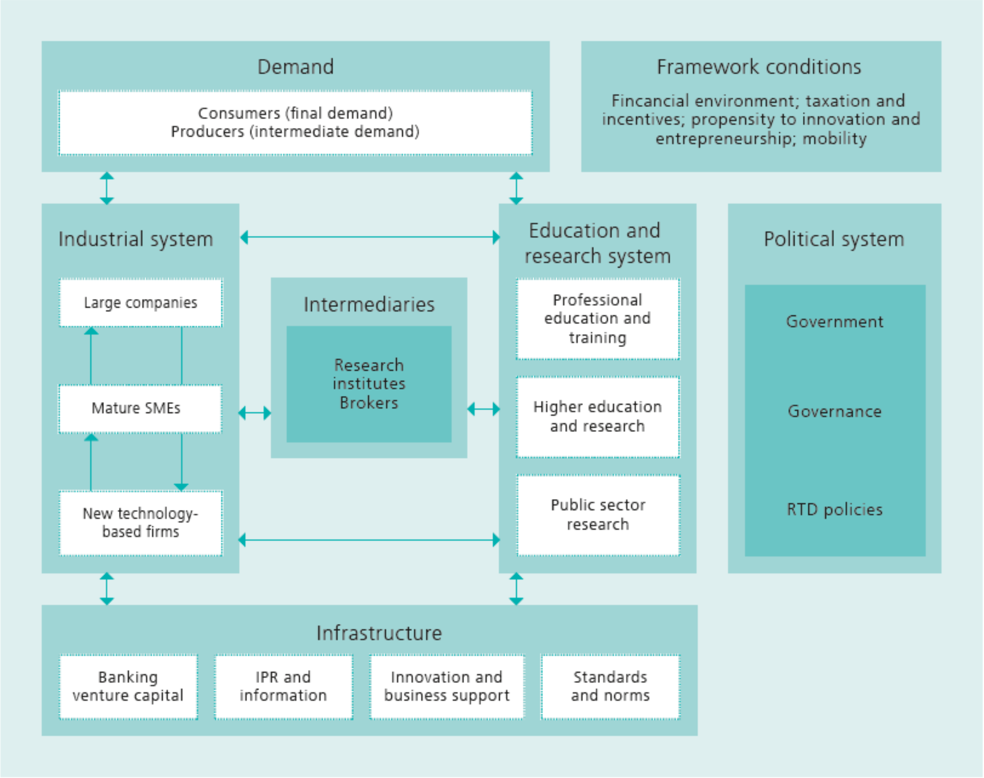
Technology and knowledge transfer

- **Business disciplines** tend to focus on stages of technology transfer, particularly relating design and production stages, as well as sales, to transfer (e.g., Teese 1976, Lake, 1979).
- **Management researchers** focus on intrasector transfer (Rabino 1989, Chiesa/Manzini 1996) and on the relation of technology transfer to strategy (Laamanen/Autio 1996, Lambe/Spekman 1997).
- **Industrial economists** (Hagedoorn 1990 and 1995, Niosi 1994, Niosi/Bergeron 1992, Mowery et al. 1996, Kingsley/Klein 1998) focus on alliances among firms and how alliances pertain to the development and transfer of technology.

(according to Bozeman 2000, p. 630)

General framework: Innovation system

- **Macro perspective:** industrial system, education and research system, system of intermediaries, political system
- **Meso perspective:** small and large firms, manufacturing and services, sectors/technologies, HEIs, non-university research institutes, TTOs, chambers of industry and commerce, parliament, government, ministries
- **Micro perspective:** organizations, associations, persons (single or group)

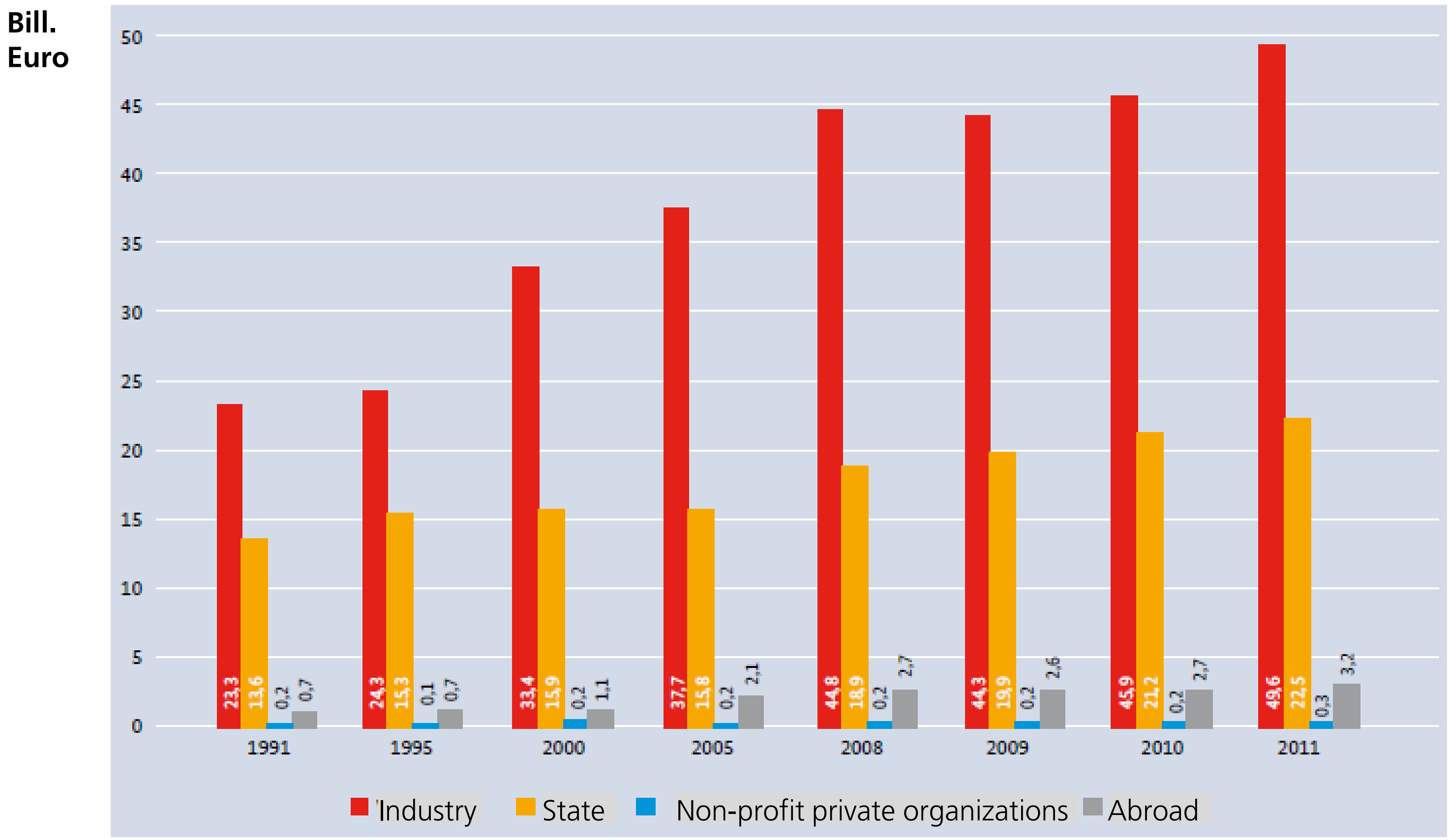


Source: Koschatzky (2012a) according to Kuhlmann and Arnold (2001, p. 2)

Gross domestic expenditures on R&D in share of GDP in Germany (%)

Source: BMBF 2014

Gross domestic expenditures on R&D in Germany according to funding sectors



Source: BMBF 2014

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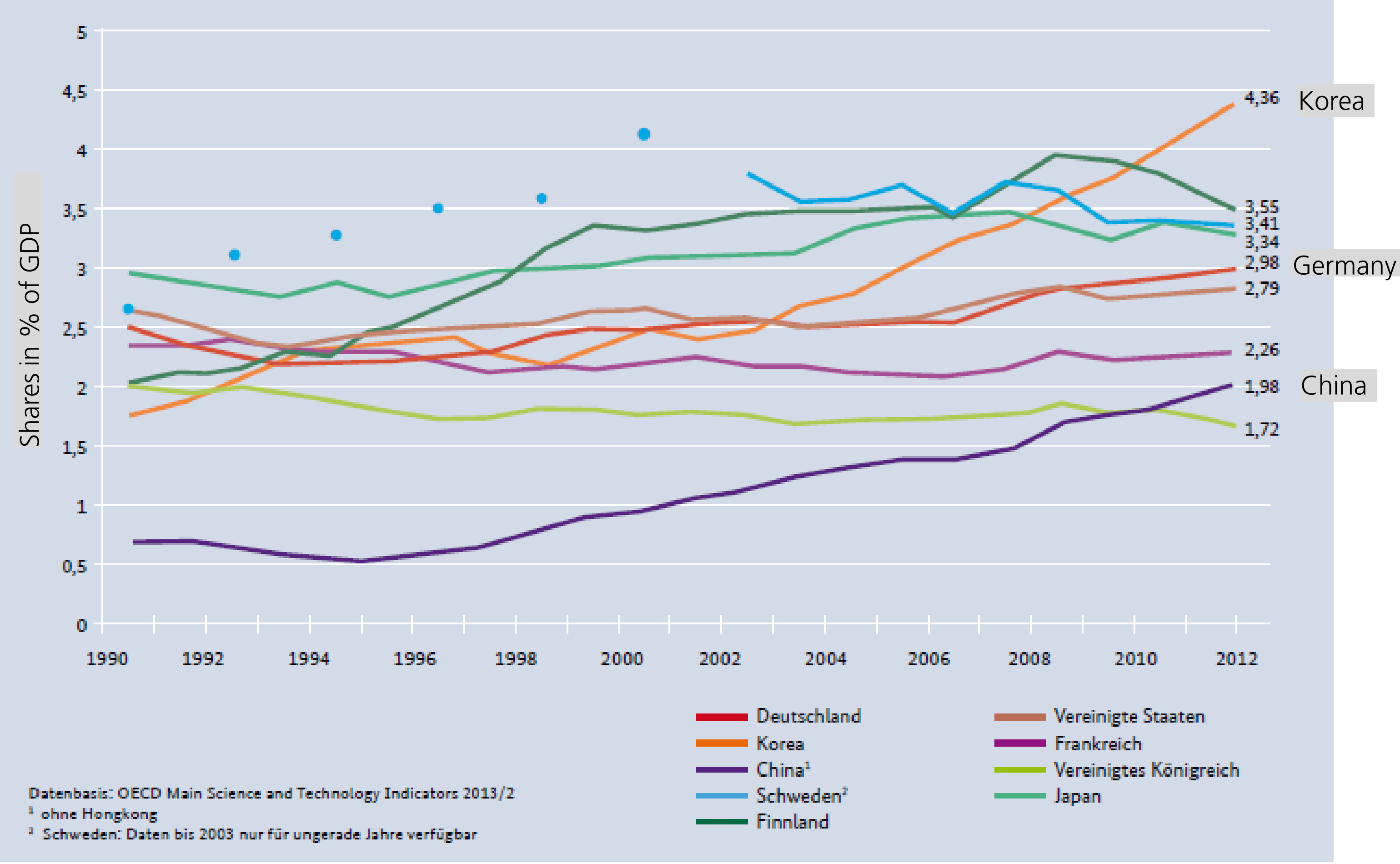
Gross domestic expenditures on R&D as shares of GDP



Source: BMBF 2014

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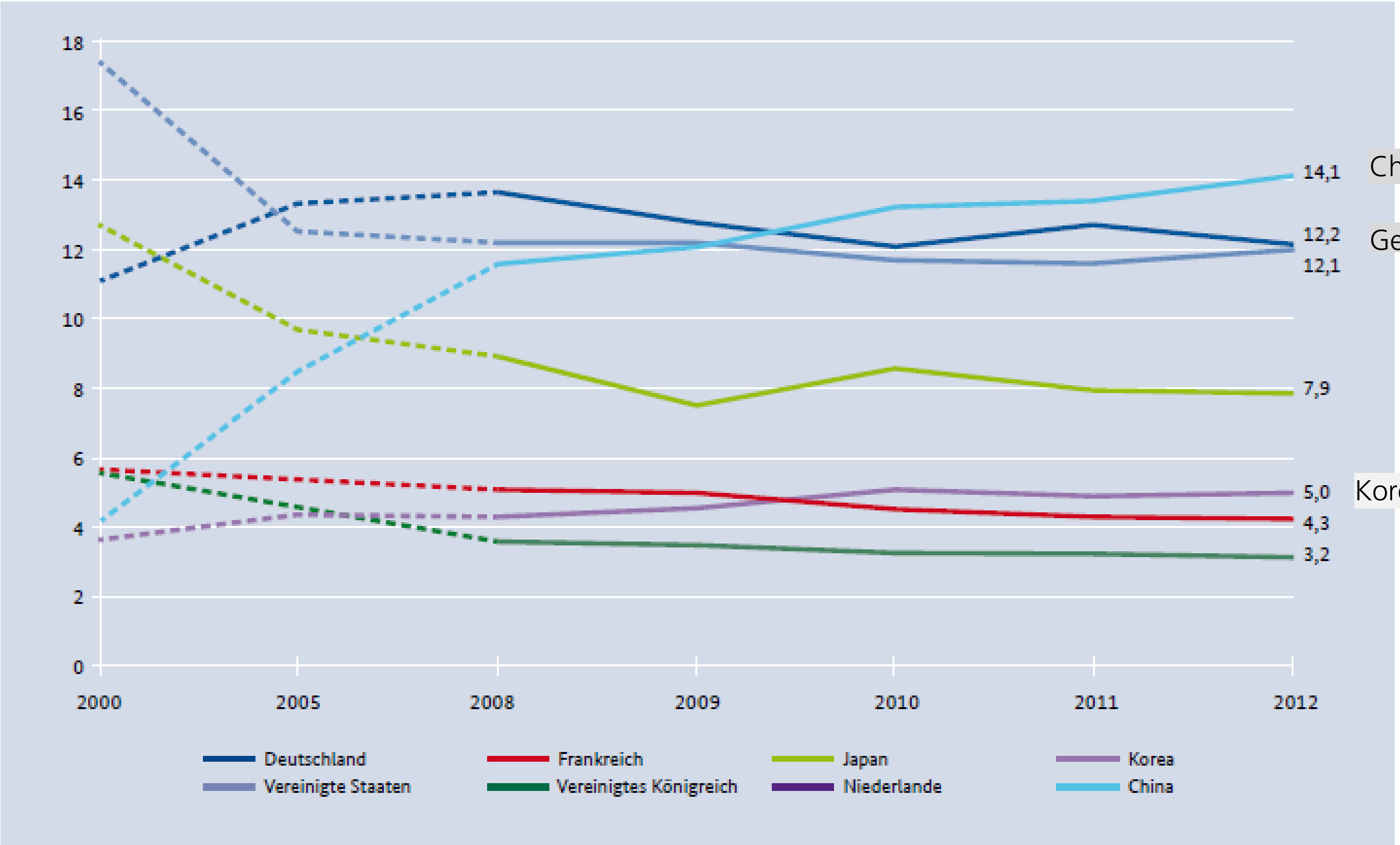
World trade shares for research-intensive goods (in %)



Source: BMBF 2014

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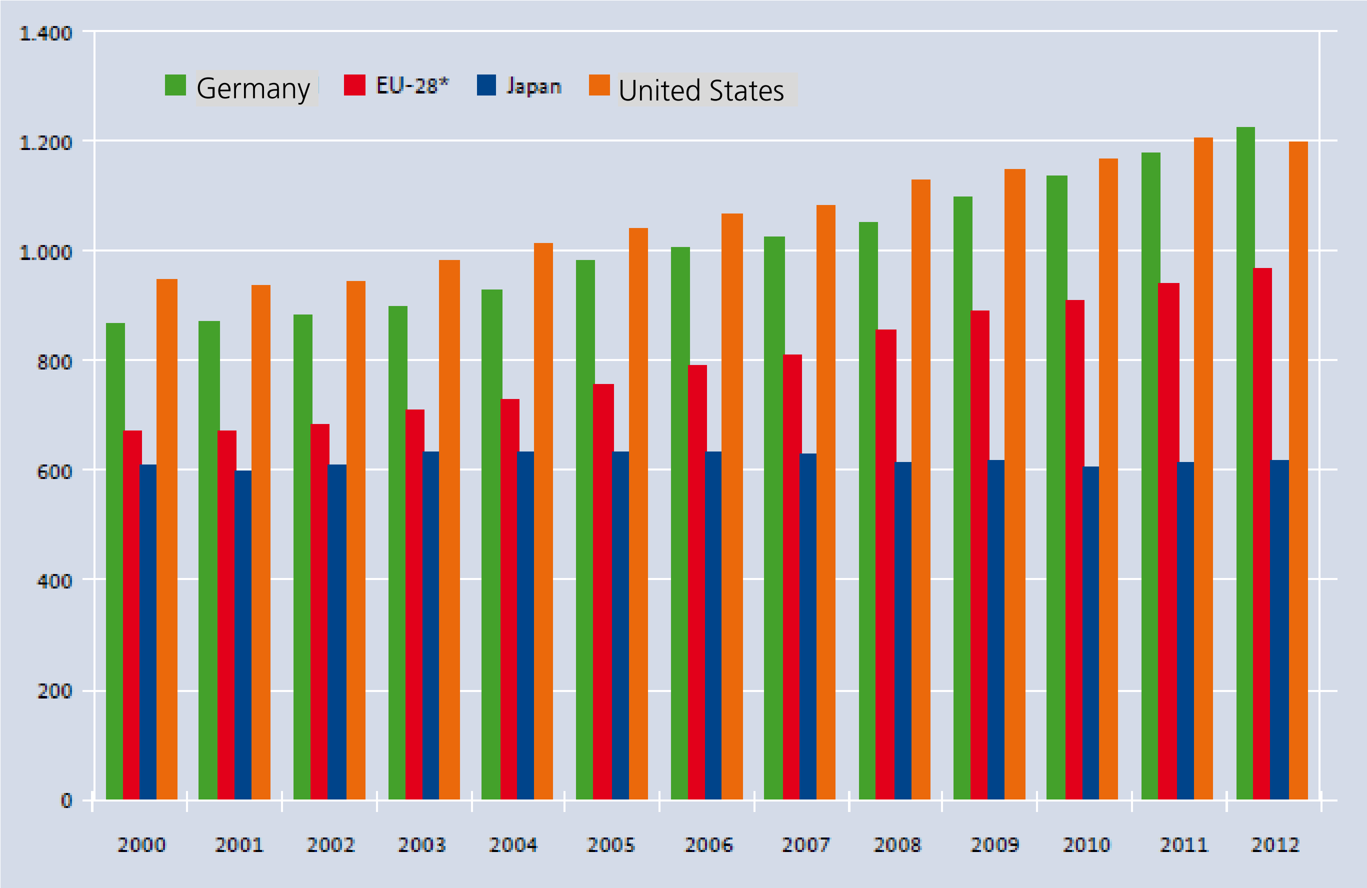
Number of scientific publications per million inhabitants



Source: BMBF 2014

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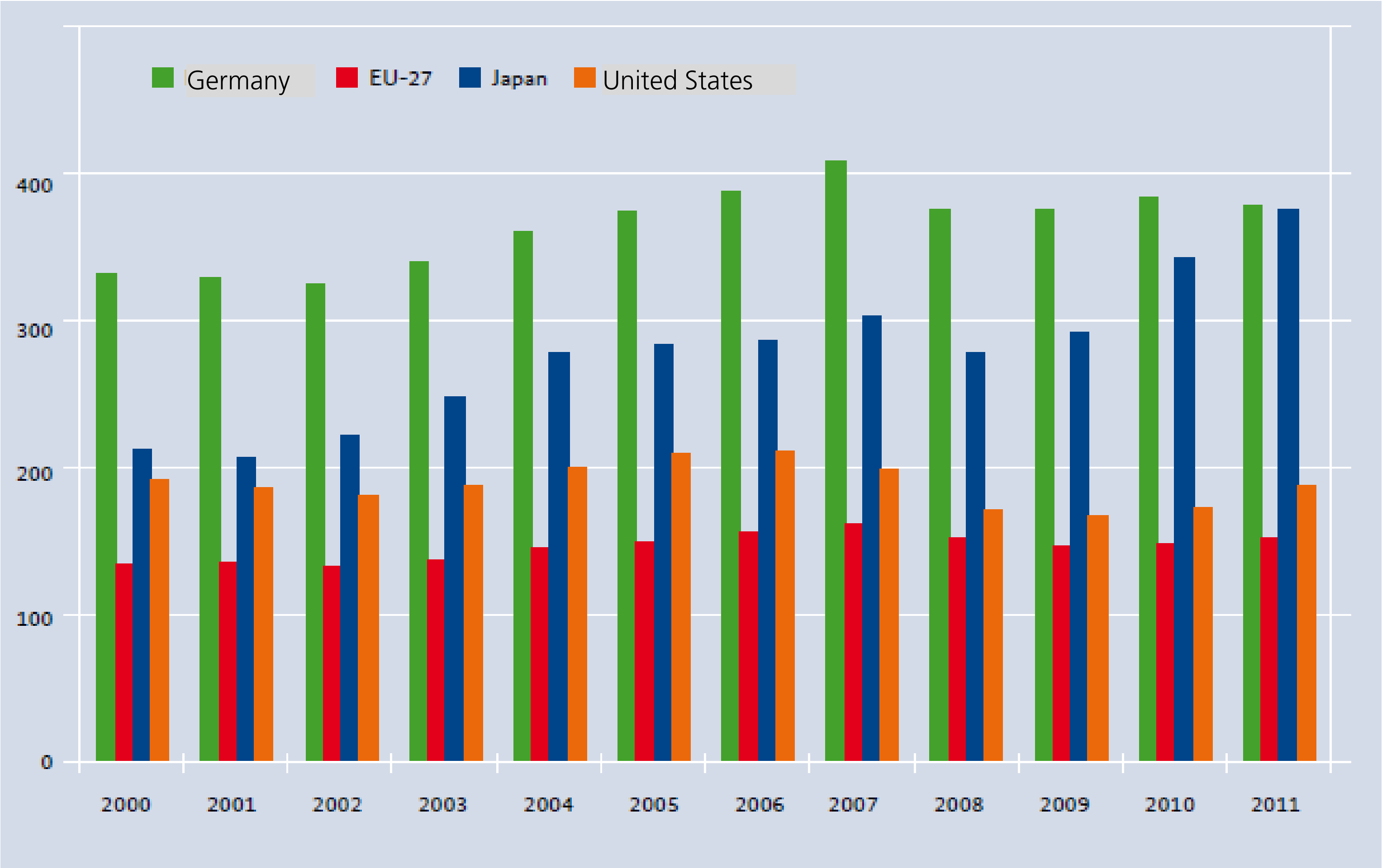
World market relevant patents per million inhabitants



Source: BMBF 2014

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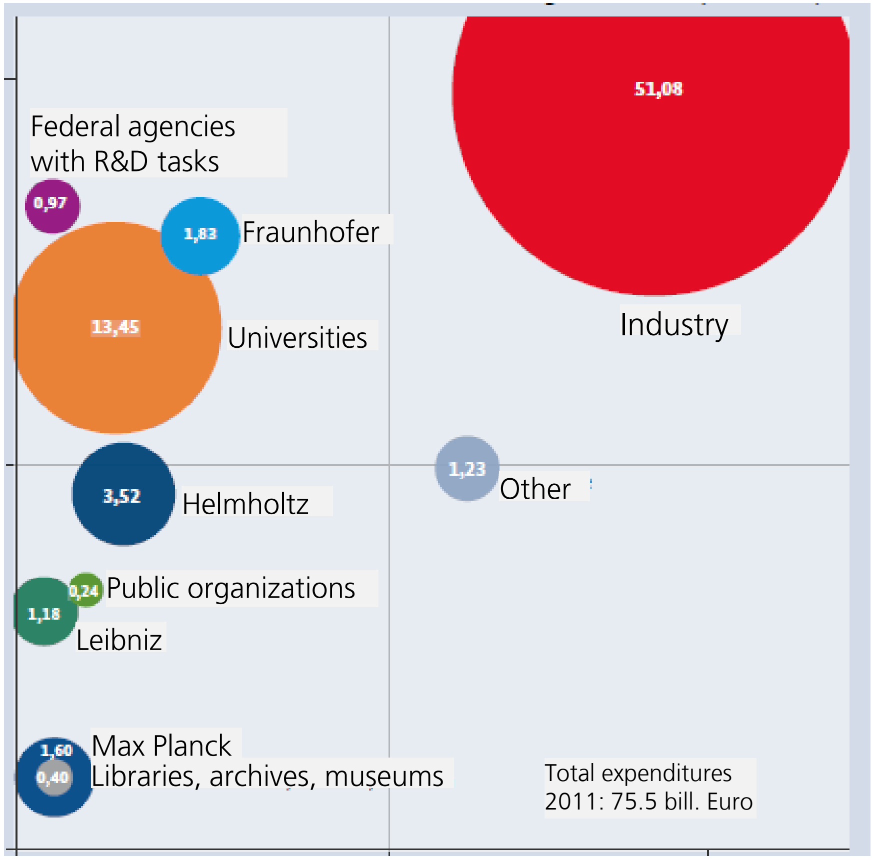
German research landscape

Applied research

Research character

Basic research



public **Funding** private

Source: BMBF 2014

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Case study: Fraunhofer Society

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Joseph von Fraunhofer (1787 – 1826)

© Deutsches Museum

Researcher

➔ Discovery of the "Fraunhofer lines" in the solar spectrum

Inventor

➔ New methods for processing lenses

Entrepreneur

➔ Director and partner in a glassworks

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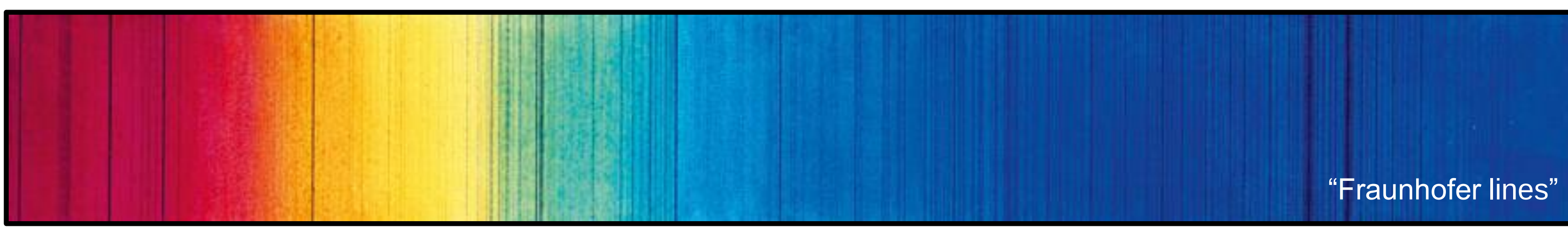
Fraunhofer Society, the largest organization for applied research in Europe

- 67 institutes and research units
- More than 23,000 staff
- €2 billion annual research budget totaling. Of this sum, more than 1.7 billion euros is generated through contract research
  - Roughly two thirds of this sum is generated through contract research on behalf of industry and publicly funded research projects
  - Roughly one third is contributed by the German federal and Länder governments in the form of base funding



Joseph von Fraunhofer

The Fraunhofer-Gesellschaft

Discovery of the "Fraunhofer lines" in the solar spectrum

Researcher

Research and development on behalf of industry and state

New methods for processing lenses

Inventor

mp3 music format, white LED, high-resolution thermal camera

Director and partner in a glassworks

Entrepreneur

Research volume: approx. €2 billion annually

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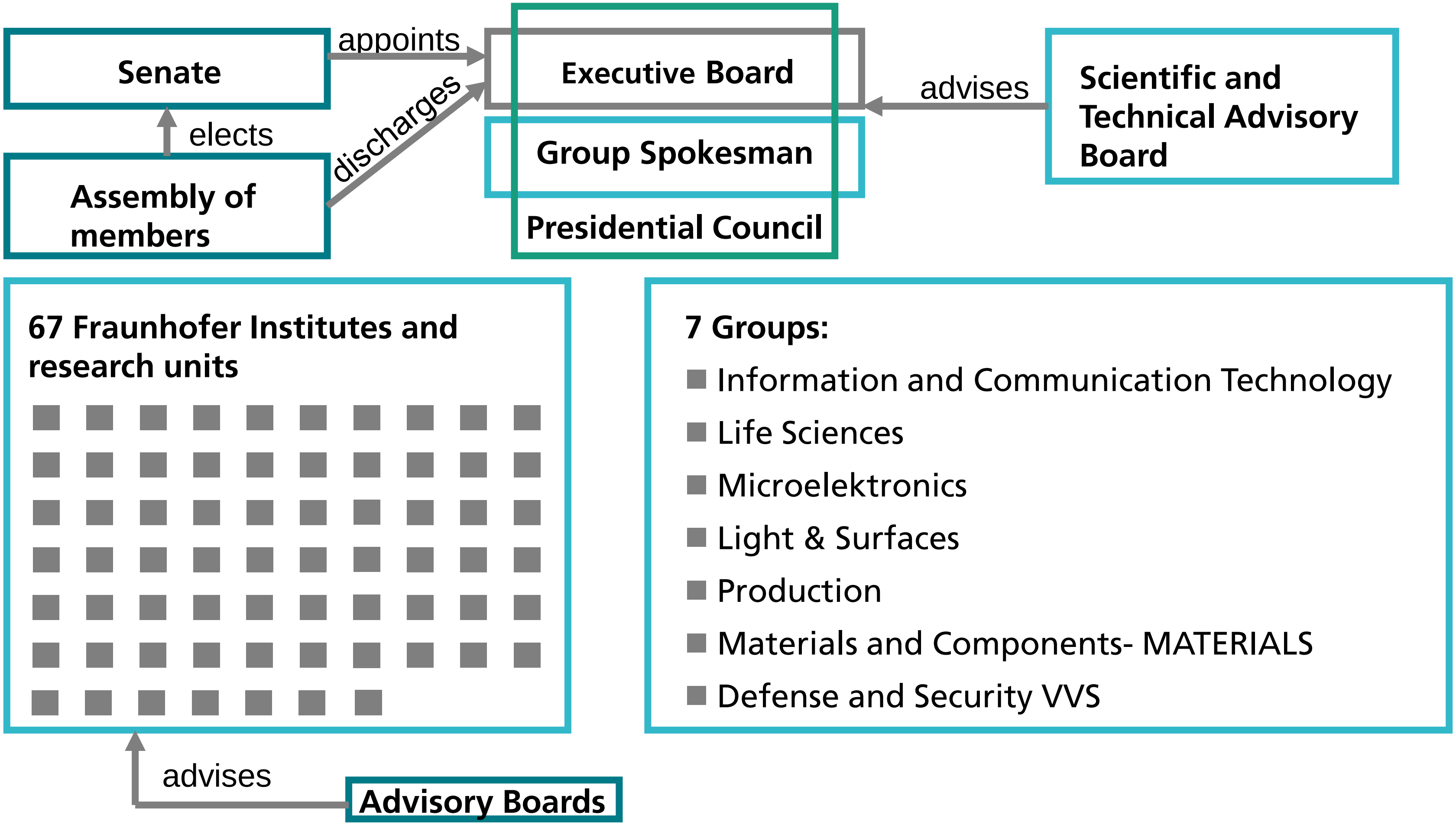
Structure of the Fraunhofer-Gesellschaft



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The Fraunhofer Society: Locations in Germany

- 67 institutes and research units
- more than 23,000 staff

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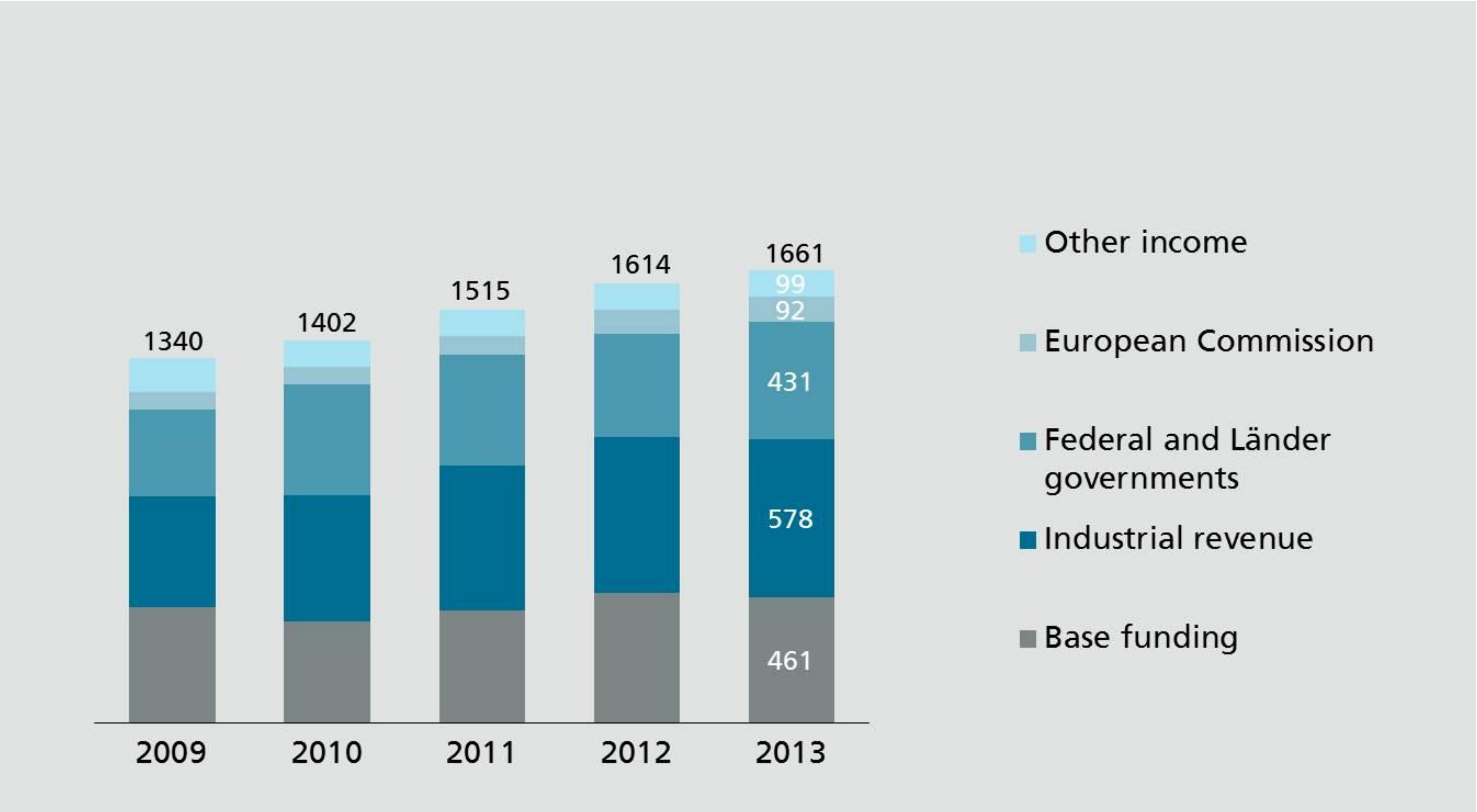
Contract research: 2009 – 2013 in € million



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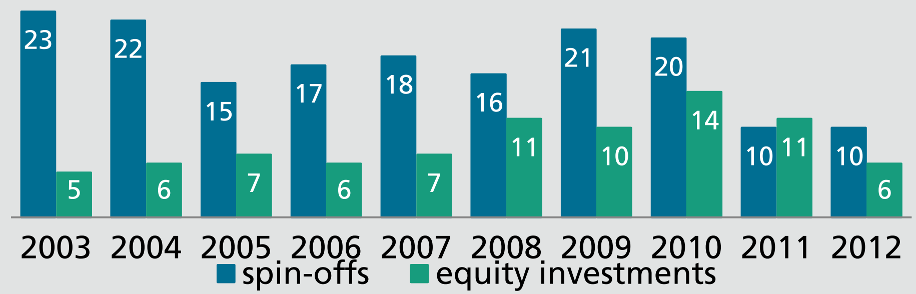
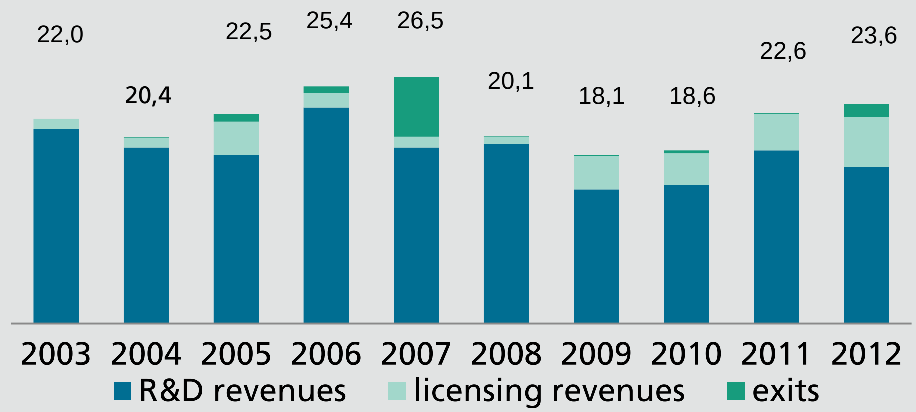
Fraunhofer Society spin-offs

Number of spin-offs and equity investments



Revenues from spin-offs in € million



Per year:

➔ ~ 40 spin-off projects

➔ ~ 15 spin-offs

➔ ~ 10 equity investments

- Currently: ~ 80 equity investments in the portfolio
- Rate of insolvency for equity investments within first 3 years after being founded: < 4%
- R&D and licensing revenues from young spin-offs are approximately € 20 million p.a.
- Revenues from sale of company shares (exits) are volatile and can be realized only in the long term.

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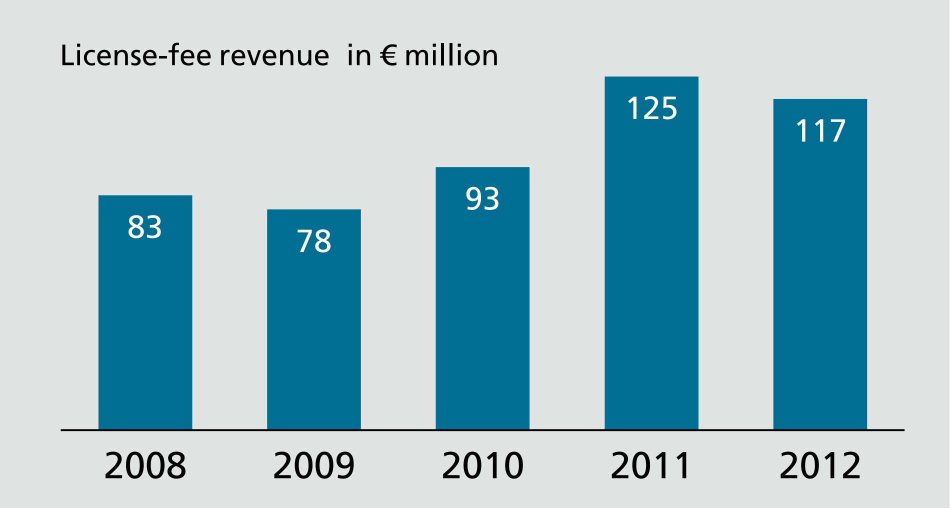
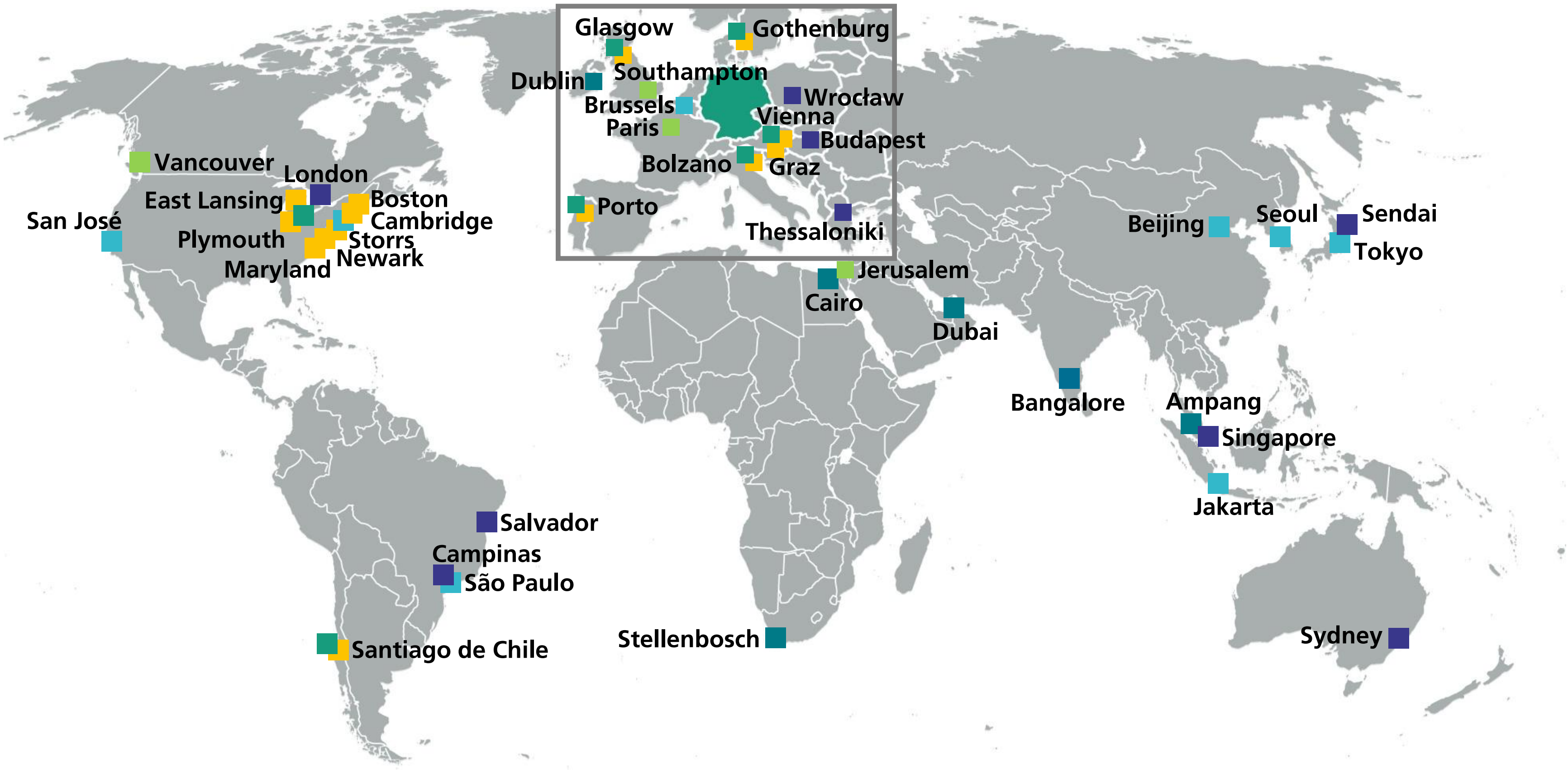
Growth in inventions and patents 2008 – 2012

	2008	2009	2010	2011	2012
Active rights an patent applications*	5015	5235	5457	5657	6103
Invention disclosures	690	691	694	671	696
Patent applications	565	563	520	500	499

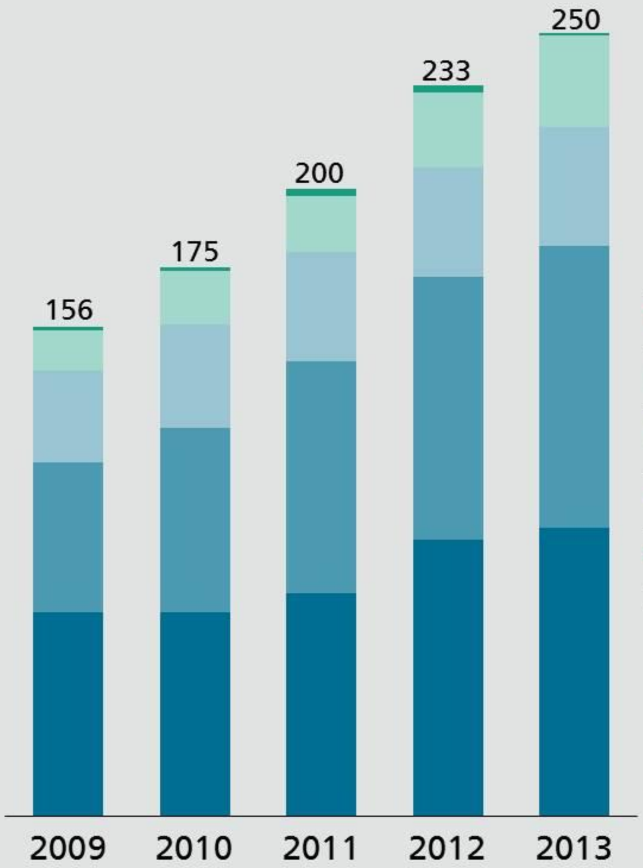


* As of Dec. 31

Fraunhofer worldwide



International revenue of the Fraunhofer Society: 2009 – 2013 (in € million)



	2009	2010	2011	2012	2013
Other countries	1	1	2	2	1
Asia	13	17	18	24	29
North and South America	29	33	35	35	38
European Countries	48	59	74	84	90
European Commission	65	65	71	88	92
Total:	**156**	**175**	**200**	**233**	**250**

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COOPERATION MODELS: Different ways of working with Fraunhofer

ONE-OFF CONTRACTS	LARGE-SCALE PROJECTS WITH MULTIPLE PARTNERS	INTERNATIONAL COOPERATION
→ Solve the problem → Launch the innovation in the business or the marketplace	→ Cooperation between multiple Fraunhofer institutes, external partners and companies	→ Fraunhofer offices abroad
STRATEGIC PARTNERSHIPS	**INNOVATION CLUSTERS**	**SPIN-OFFS**
→ Long-term partnerships that evolve from non-contract, pre-competitive research	→ Regional partners from research, industry and universities	→ Fraunhofer researchers branch out on their own, often with the customer taking a stake

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Changes in innovation systems

- Due to the dynamic character of innovation processes, also **innovation systems have to continuously adapt** to new challenges and competitive change.
- Although path dependency results in quite stable organizational structures over a certain period of time, **organizations itself and interfaces between them change** more frequently.
- Changes induced by the increasing globalization since the early 1990s and the increasing complexity and interrelatedness in innovation processes had also impacts on the German innovation system.
- **New organizations** emerged, **new forms of governance** were introduced (e.g. in the higher education system), **new policies, instruments and programs** were implemented (e.g. cluster promotion, Hightech Strategy).
- Also **interfaces and transfer bridges** change: Collaborations between **heterogeneous partners** (i.e. belonging to different sub-parts of an innovation system) developed and the modes of collaboration between them changed.

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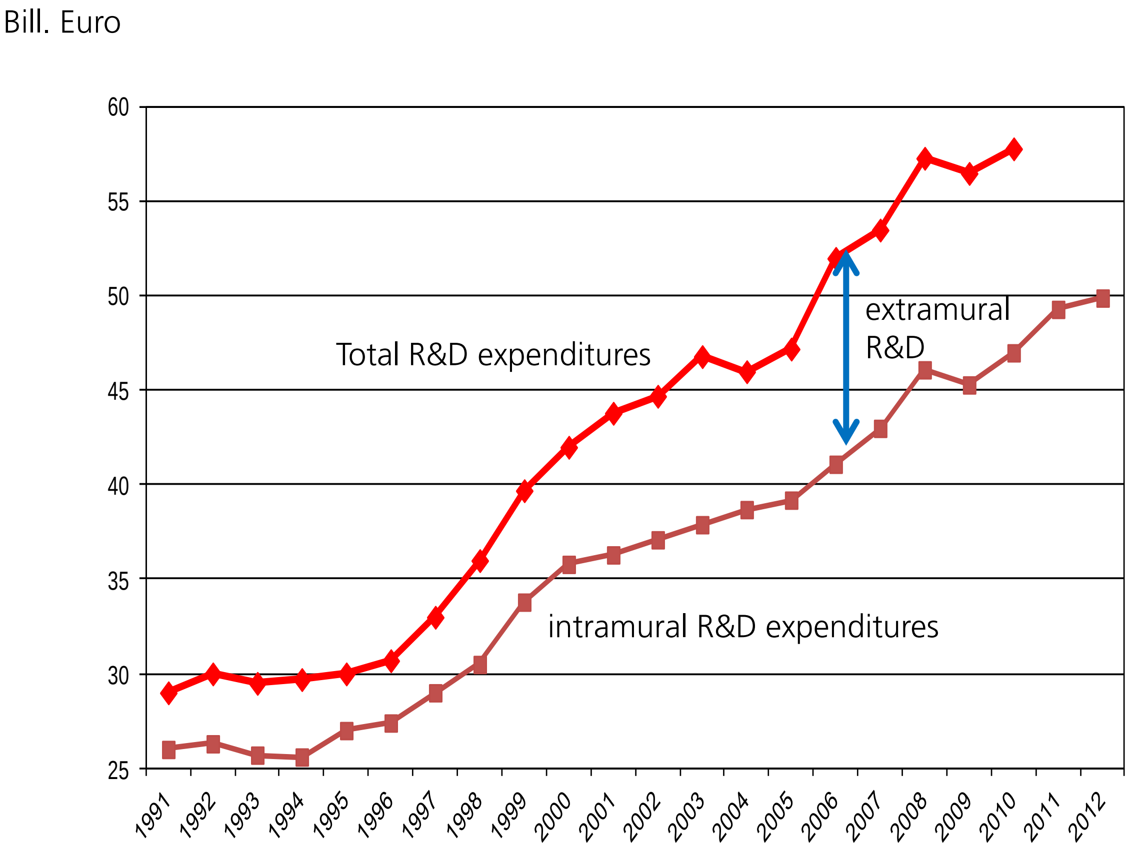
Changes in the industrial sector

- In the course of globalization and the increasing science orientation in technology development, the **complexity in technology and product development** increases further.
- Own entrepreneurial **resources** (knowledge, capital) **are often insufficient** to master this complexity.
- This results in **changes in the interface between science and industry** in the German innovation system - (large) companies are looking for access to long-term strategic research.
- Universities and non-university research institutions are attractive **research partners** in this context.

Structural changes in industrial R&D spending in Germany



- Since the mid 1990s, total R&D expenditures and the share of external R&D expenditures has increased (outsourcing)
- Other firms and universities profited most
- Most of industrial funded R&D is short-term and market-oriented development
- Only recently, the tendency towards more long-term oriented research increased

Source: Stifterverband Wissenschaftsstatistik, several years

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Changes in the higher education sector

- The **range of tasks of universities** has increased significantly without a corresponding increase in allocated financial resources.
- In the context of increasing **university autonomy**, new public management principles have been applied to the universities and self-control has been enhanced.
- New organizational possibilities have been opened which allow universities to act as **strategic actor** by their own.
- In this context, the emergence of **"entrepreneurial universities"**, the **"boundary-spanning roles"** of new university units (Youtie and Shapira 2008) and the **"third role" of universities**, i.e. their active contribution to regional development (Gunasekara 2004; Westnes et al. 2007) are discussed.

New tendencies of research cooperation between universities and industry

- **Significant change of the role of universities** in innovation systems: entrepreneurial behaviour of universities, entrepreneurship education, targeted spin-off promotion programs play an important role.
- Long-term, stable institutional structures to organize research and technology **transfer** are more and more replaced **by flexible solutions** and problem-related research cooperations between science and industry.
- Implementation of **Public-Private Partnerships** currently discussed in policy and policy research (e.g. TIP Activity on Opportunities and Options for Public-Private Partnerships at the OECD).
- **Examples** are: Industry-University Cooperative Research Centers (IUCRCs), Centers of Excellence (CoEs), Competence Research Centers

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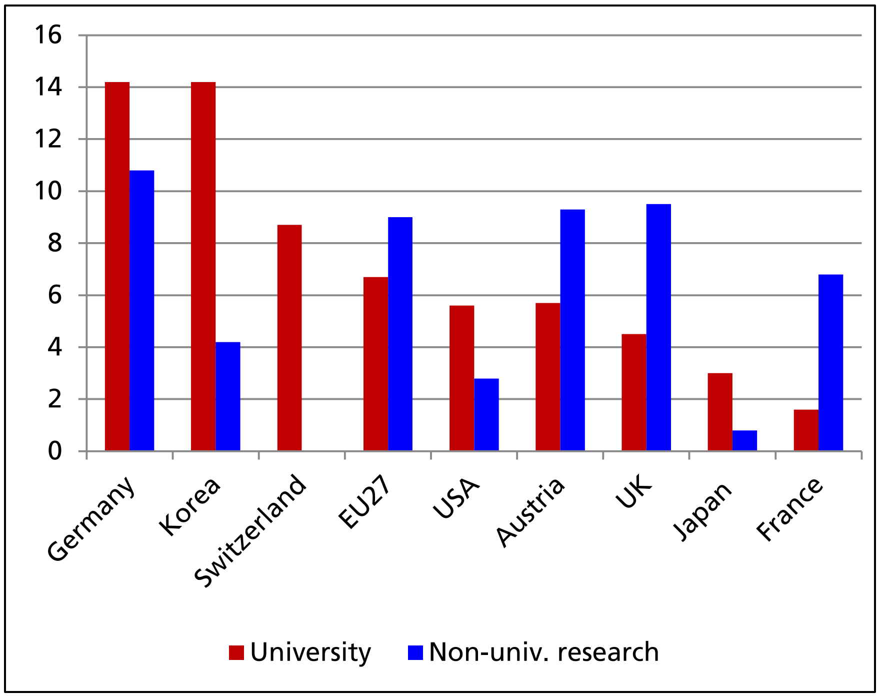
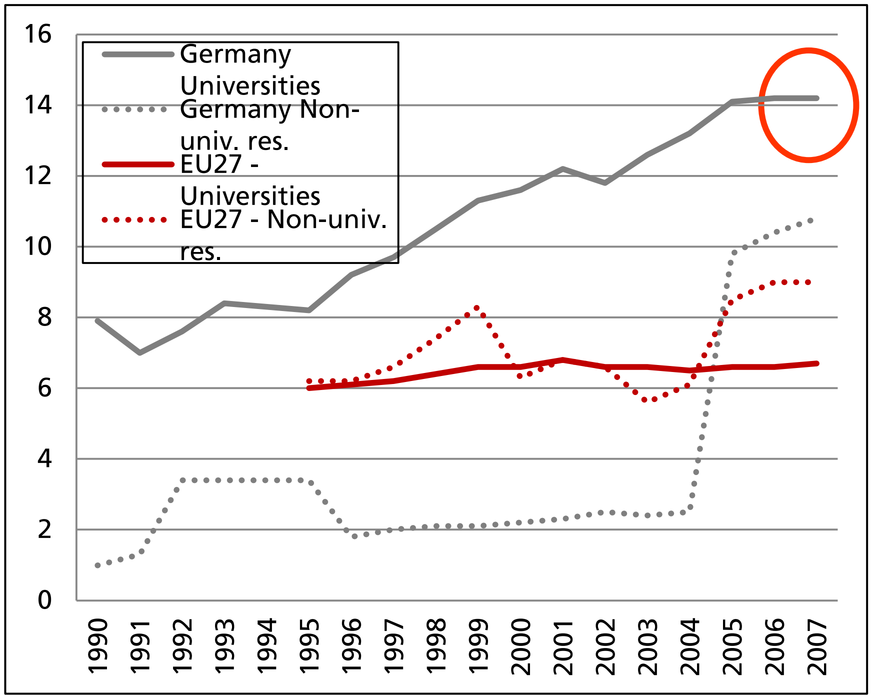
Relevance of industrial funding in university research

Share of university R&D activities funded by industry 2007 by country (in %)



Source: OECD: MSTI 5/2010

Share of university R&D activities funded by industry 1990-2007 (in %)



Source: OECD: MSTI 5/2010

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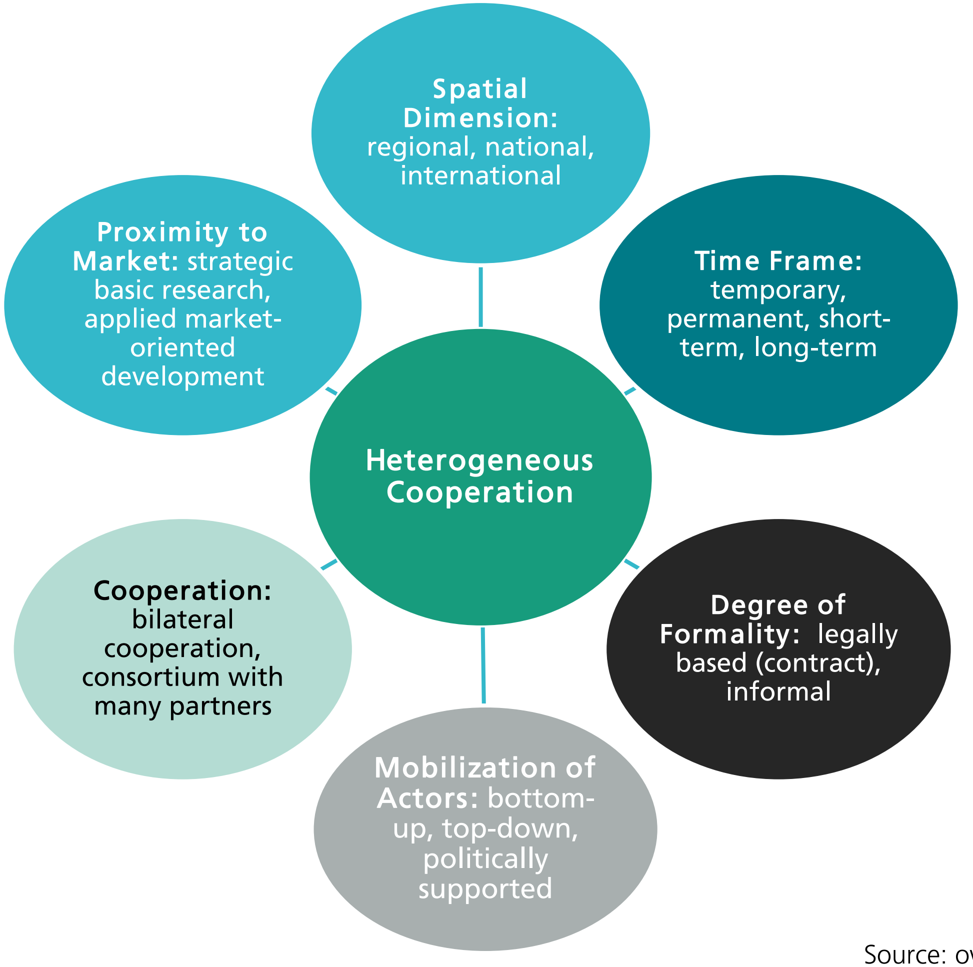
Starting points for partnerships between heterogeneous partners



Source: own draft

The new High-Tech Strategy – understanding what belongs together

The new High-Tech Strategy is based on five pillars

1	Priority challenges with regard to value creation and quality of life	Enhance competitiveness Increase prosperity
2	Networking and transfer	Strengthen cooperation Support implementation
3	The pace of innovation in industry	Increase innovative strength Enhance value creation
4	Innovation-friendly framework	Provide the basis for creativity and innovation
5	Transparency and participation	Arouse curiosity Promote forward-thinking

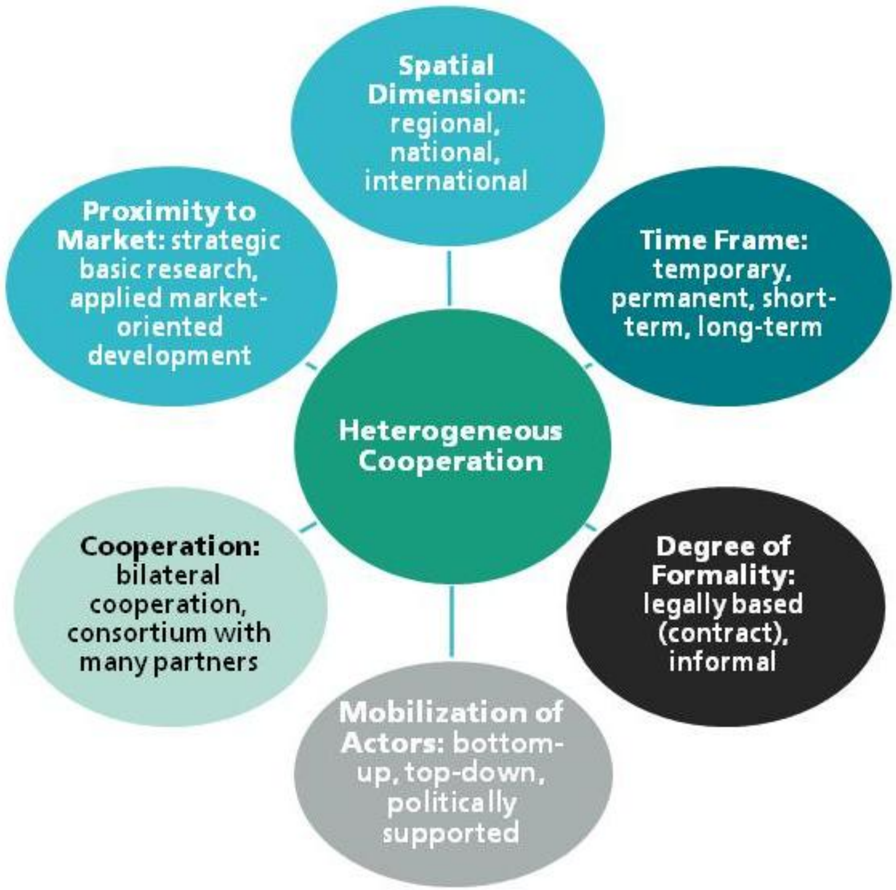
Public support of heterogeneous cooperations in Germany

- In its report 2009, the Expert Commission for Research and Innovation (EFI) suggested that strategic cooperations between industry and research organizations should be encouraged and "active political support should be provided for further partnerships" (EFI Report 2009, p. 41).
- Based on this recommendation, BMBF formulated and implemented the funding initiative **"Research Campus" (Forschungscampus)** which is part of the Hightech Strategy 2020.

- Its objective is to promote collaboration between partners from industry and research organizations by **combining resources** in order to **develop new research fields** in a **middle to long-term perspective** in the way of **public-private partnerships** located **at the campus of a university or research institute.**
- **Strategic pre-competitive research** should be strengthened and **leverage effects** by public funding for an increased private investment be created.

Starting points for the establishment of new forms of collaboration

- Increasing **freedom and** levels of **autonomy of public research organizations** and increasing flexibility of institutional structures.
- In addition to contractual bilateral relations **new structures and organizations** at the interface between science and industry emerge.
- Starting points: collaborations in which actors from different, previously separate organizations **interact and explore new forms of cooperation** ("Heterogeneous cooperation").



Source: Koschatzky (2013)

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International Public Private Partnership Programs

Country	Name	Duration	Responsibility	Type
Australia	Cooperative Research Centres	1990-2010	Ministry of Industry	Competence Centre
Austria	Kplus / Kind, Knet; COMET	1998-2009; since 2006	BMVIT/TiG, FFG BMWA/FFG	Competence Centre
Estonia	Competence Centres Estonia	2004-2007	Ministry of Industry	Competence Centre
Finland	Strategic Centres for Science, Technology and Innovation (SHOK)	since 2006	TEKE	Competence Centre / Cluster
Canada	National Centres of Excellence (NCE)	since 1989	NSERC, CHIR, SSHRC	Network
Norway	Centres for Research-based Innovation Scheme (SFI), Centres of Excellence scheme (SFF)	2006-2014	Research Council of Norway	Competence Centre
Sweden	Swedish Competence Centres Program VINN Excellence Center	1994-2003; 2003-2018	NUTEK/STEM/ VINNOVA	Competence Centre
USA	Engineering Research Centres (ERC), Industry/University Cooperative Research Center (IURCR)	since 1985 since 1979	National Science Foundation	Competence Centre

Source: Kaplun 2013

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Science-Industry interaction support in Germany - Research Campus

A more recent example is the **Research Campus Program**

- National program, competition-based
- Applied basic research with **long-term market orientation**
- In September 2012, **10 Research Campus projects** were selected
- Most RC enter the **main phase at the end of 2014**. **Nine** are still operating.
- **Preparation** and **main phases** will be supported up to altogether **15 years** with a maximal amount of 2 mill. Euro per year
- The selected Research Campus can be regarded as pilot models for other universities and companies

Source: own figure

Three characteristics form the bases for establishing a Research Campus

FORSCHUNGS CAMPUS

Three distinct characteristics shall be fulfilled:

- **Proximity** – the bundling of research activities and competencies at one location, as possible on a university or public research campus
- The medium- to long-term **adaptation of a specific research topic**, ideally within a research program
- A **mandatory public-private partnership**

In practice

- The RCs are active in diverse fields like energy, health/medicine, automotive/mobility
- Several companies should be part of a Research Campus (RC), ideally SMEs; but large (multinational) companies are drives in most cases
- Together, the partners of a RC shall contribute at least 50% of total budget
- Various forms of organisational forms and contracts are established suiting the specific demand of each RC. One important aspect IPR
- Working "under one roof" sometimes implies considering aspects related to labour protection, contracts and payment

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Subjects of the Research Campus

Campus	Subject	Location
ARENA 2036	Development of multifunctional composite materials	Stuttgart
Digital Photonic Production	3D-printing and construction of composites	Aachen
Electrical Nets of the Future	Direct current voltage for power transmission	Aachen
EUREF	E-mobility and mobility and urban concepts	Berlin
INFECTOGNOSTICS	Efficient and rapid on site proof of infection agents	Jena
M2OLIE	Medical intervention environment regarding cancer	Mannheim
MODAL AG	Mathematical optimization of complex processes	Berlin
Open Hybrid LabFactory	Hybrid light construction for automobiles	Wolfsburg
STIMULATE	Screening of minimal-invasive methods in medicine	Magdeburg

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Support of underlying hypotheses

Evaluations of cooperation programs from the USA, Sweden and Austria show (Kaplun 2013):

- **Proximity** is a success factor for a long-term and sustainable cooperation between science and industry.
- A **middle to long-term perspective** is essential for basic research, but can be a problem for companies, because this is beyond their planning range.
- A **sustainable commitment** in the form of a legally regulated public-private-partnership is the basis for long-term cooperation, reduces conflict potential, but cannot always be realized on an "eye level" basis.

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Regional perspective

- **Prior structures** with **long existing network relationships** existed in all research cumpus: some since 20, mostly for 5-10 years.
- In the research campus **existing (regional) networks were transferred to other structures and liabilities**.
- **Experiences** and **relationships of trust** have already been established on this basis.
- **Large industrial partners** often **do not come from the region**, but have a branch office in the region (e.g. Siemens).
- **Smaller companies** usually have **a location in the region** (e.g. Analytik Jena AG).
- All industrial core partners should be represented with **staff on site** (**campus model**).
- Therefore **network building** firstly occurs **locally / regionally**.

SME perspective

- **SMEs are involved**, but in different ways.
- Participation depends on several **factors**: subject and aim of the research campus, required funding of participation, industries and actor constellations (e.g. supply chains) in the subject area of the research campus, regional economic environment.
- In regions where large companies are missing (e.g. in the **eastern federal states**), the **share of SMEs** among the partners **is higher** than in regions with a mixed company structure.
- **SMEs** are rarely core partners (high financial commitment required), but **mostly project partners** with less decision-making and participation rights.

Network structures

- **Scientific focal actors** are universities (e.g. M²OLIE Mannheim, STIMULATE Magdeburg), non-university research institutes (e.g. MODAL Berlin with Konrad-Zuse Institute) or industry-funded higher education institutions (e.g. FEN Aachen with E.ON Energy Research Center).
- There are **bilateral constellations of actors** as the central network partners (university and a company), but also **networks with several key partners** (universities, non-university research institute, several companies).
- Within the networks, a **hierarchy** exists between core partners with centralized decision-making powers and other partners ('project partners') with limited participation rights.
- RC are **regional/local strategic networks** with a high degree of centralization and include public and private actors. In this sense, they are a hybrid form of a strategic and regional network according to Sydow (1992).

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Advantages of cooperation and challenges in network creation

- **Advantages** of the cooperation in a Research Campus compared to other forms of cooperation are in view of RC managers:
  - Institutionalization and liability of co-operation (governance)
  - Close exchange under one roof enables the development of new solutions
  - Common infrastructure promotes cooperation and technological feasibility
  - Training and qualification: enrichment of teaching, attraction of undergraduate and graduate students
  - Quality label, holistic approach, long-term perspective.

- **Challenges** are:
  - Binding commitments of the industrial partners in the context of internal compliance policies and decision-making structures (board decisions).
  - Possible competitive situations
  - Involvement of SMEs
  - Optimal size of the consortium
  - Openness to new partners.

Higher education policy perspective

- For all participating universities, the research campus is an **important strategic element** and serves the higher education policy **agenda setting**.
- This includes the **complement** of existing research structures and **changes** in higher education and research profile.
- In the majority of the research campus the **university rectors / presidents** personally committed in the submission stage of the proposal or are involved in different bodies of the research campus.
- In some universities, the university management allocates **financial and human resources** in a substantial amount as own funds.
- Research campus are used as an **instrument of focus formation** and are thus regarded as controversial issue in not involved disciplines.
- They equally support **regional profile building** and **national and international excellence orientation**.

Implications for the research system

- Programs like Research Campus define **new research and qualification 'spaces'** with own governance modes within universities.
- The **gap between research and validation/exploitation** is **filled with new incentives** (as element of a long-term research agenda).
- For universities the Research Campus represents an additive **strategic tool for excellence orientation beyond mere scientific excellence**.
- Companies get **access to basic research** with a longer-term application orientation.
- **Collaboration** between science and industry is **redefined** ("under one roof")
- The **mode and scope of firms' internal R&D** is changing.
- The **boundaries** between organizations (industry / research) **are becoming increasingly blurred**.

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Conclusions

- Heterogeneous cooperations (public-private partnerships) have a **longer history in other countries** than in Germany.
- They are a clear indication (besides other developments) for **reorganizing the division of labour in strategic R&D** between industry and the research sector.
- Transfer interfaces become more flexible and the new modes of collaboration reflect the **changing role of universities** in the German research system.
- These kind of cooperations are a **'temporary marriage'**. They must demonstrate an added value against other possibilities of organising research activities.
- The ResearchCampus program by BMBF is an **attempt to establish this form of collaboration in Germany**.
- Based on ongoing experiences it has to be evaluated whether these strategic PPPs become a **new and sustainable element in Germany** and how they **affect the whole research system** (i.e. new role and self-conception of universities).

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Thank you for your attention!

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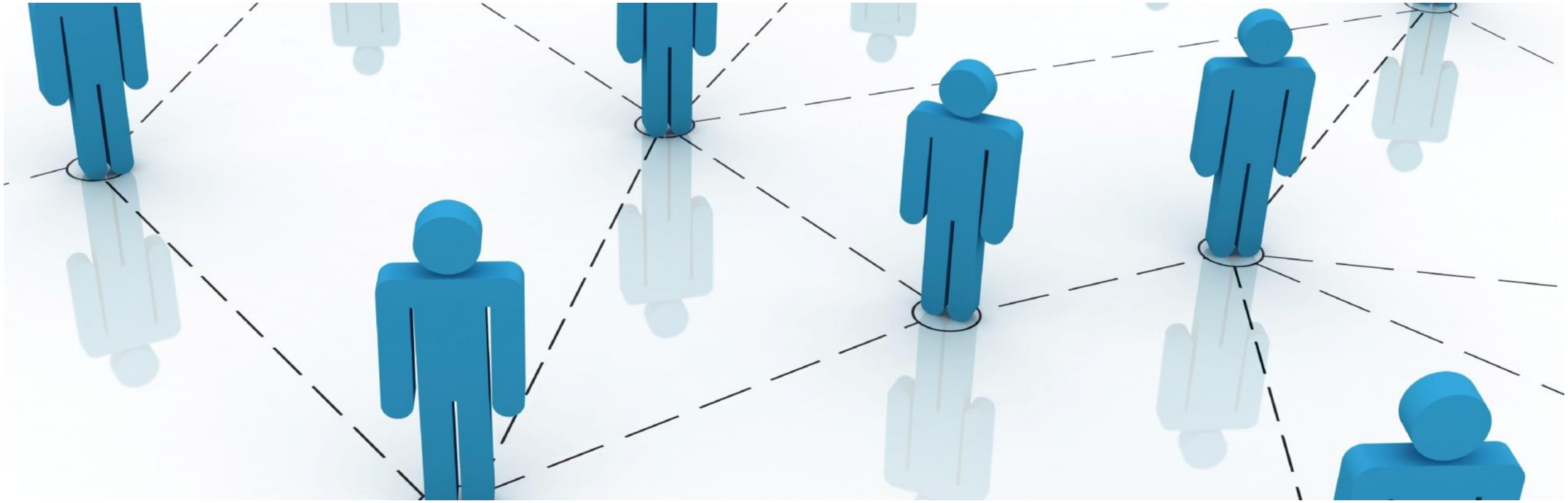

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