FZID Discussion Papers

CC Innovation and Knowledge

Discussion Paper 96-2014

NETWORK EVOLUTION, SUCCESS, AND REGIONAL DEVELOPMENT IN THE EUROPEAN AEROSPACE INDUSTRY

Daniel Guffarth
Michael J. Barber

Universität Hohenheim | Forschungszentrum Innovation und Dienstleistung
www.fzid.uni-hohenheim.de

Discussion Paper 96-2014

Network evolution, success, and regional development in the European aerospace industry

Daniel Guffarth
Michael J. Barber

ISSN 1867-934X (Printausgabe)
ISSN 1868-0720 (Internetausgabe)

Network evolution, success, and regional development in the European aerospace industry

Daniel Guffarth
University of Hohenheim, Economics Institute, Innovation Economics (520i) &
MBtech Group GmbH & Co. KGaA

Michael J. Barber
Innovation Systems Department,
AIT Austrian Institute of Technology GmbH, Vienna, Austria

E-Mail: daniel.guffarth@uni-hohenheim.de, michael.barber@ait.ac.at

Abstract

The success breeds success hypothesis has been mainly applied to theoretical network approaches. We investigate the European aerospace industry using data on the European Framework Programmes and on Airbus suppliers, focusing on the success breeds success hypothesis at four levels of analysis: the spatial structure of the European aerospace R&D collaboration network, its topological architecture, the individual actors that make up the network, and through a comparison of the Airbus invention and production networks. On the spatial level, SBS is favored: successful regions maintain their position and grow on a large scale, especially so for regions that have strongly participated from the very beginning. The regional hub structure is mirrored in the architecture of the European aerospace R&D collaboration network, where well-connected hub organizations play a key role in shaping the structure of the network through their many collaborative partnerships and do so in a way that strategically positions themselves with greater ability to access and regulate knowledge flows, as assessed by several centrality measures. Only successful organizations have the ability to form so many ties, with success thus breeding success in the European aerospace R&D collaboration network. The importance of the core organizations made clear through the centrality analysis is further supported by the analysis of weak ties, where we observe that the core organizations are connected to the rest of the network with many weak ties, thereby confirming their outstanding positions in the European aerospace R&D collaboration network as being able to access knowledge or other resources. With the combination of the R&D collaboration network and the Airbus production network on a spatial level, we see additional support for SBS, as those regions whose actors are frequent participants in both networks show the greatest share of successful actors. The European aerospace industry shows an ambidextrous character as a whole, which is nonetheless insufficient to avoid recent and future challenges demanding a strong emphasis on production skills.

JEL Classification: D85, L14, L93, O38, R11, R12, Z18

Keywords: R&D collaboration network, success breeds success, aerospace industry, European Framework Programmes

1. Introduction

Aircraft (and also satellites and space applications) are complex products in the sense that they consist of technologically interconnected subcomponents (Baldwin and Clark 2000, Frenken 2000). Due to this technological complexity—prevalent in aerospace since its inception, and rising exponentially with the advent of new aircraft — collaboration is a powerful tool to access, integrate and use external knowledge. External R&D collaboration in general has a positive influence on the innovative success of companies. The interplay of internal R&D and external R&D collaboration can be seen as most promising, as suggested by Hagedoorn and Wang (2012). According to Miotti and Sachwald (2003) a central motive for establishing collaborative relationships is to access complementary knowledge bases of the partners.

Especially in industries with complex products, different life cycle stages of different sub-systems or components complicate industry analysis on an aggregated level. Thus, we consider an industry as a population of firms and research institutes active in invention, production, and—after successful commercialization—innovation (product and process).[1] The invention side can be viewed as R&D collaboration and the production side can be viewed as the commercialization of invention resulting in an innovation, giving rise to a production network. As the actors of the population are interconnected through research and production concerns, both an invention network and a production network emerge. The composition and structure of pan-European networks per se have been little studied to date (exceptions include Barber et al. 2006, Roediger-Schluga and Barber 2008, Breschi and Cusmano 2004, and Guffarth and Barber 2013, Almendral et al. 2013, Biggiero and Angelini 2014), but it is clear that collaboration is not only needed on the innovation side– collaboration and a trustful relationship constitute the backbone for the production side (Mentzer et al. 2001, Benton and Maloni 2005). Therefore by seeking and exploiting new knowledge that is not owned by current production partners, the innovation network and the production network can change the industry structure and its composition. As argued by Tushman and O'Reilly (1996), organizations consequentially must develop ambidextrous capabilities that enable them to cope with both the innovation and the production challenges imposed by their environment, differing the industry life cycle. Today's aircraft industry can be positioned in a growth/mature phase within the industry life cycle, where a dominant product design has been established decades earlier and OEMs face the challenge to ramp up their production and shape their production system to be more efficient.[2] Combined with the fact that learning curves, economies of scale, barriers to entry and financial resources are of considerable importance in the competitive process, large firms with intense power came to the forefront of the innovation process (Utterback 1994, Gort and Klepper 1982, Klepper 1996).

Despite the serious challenges on the process side of innovation and the changes in the production network, we define the aerospace industry as a Schumpeter Mark II sector, which is characterized by creative accumulation and by the dominance of a stable core of a few large firms, with limited entry (Malerba 2004), which will become evident in sections 3 through 5. Cumulativeness conditions capture the properties that today's innovations form the starting point for tomorrow's innovations, which can be equated with *success breeds success* (SBS) (Mansfield 1968). The SBS hypothesis — closely related to the concepts of the rich-get-richer hypothesis and cumulative advantage (Barabasi and Albert 1999) —

---

[1] Nevertheless, non-inventive actions, such as imitation, are also important success factors for the commercialization of a product or process. Rothwell (1992, 2002) lists several success factors for industrial innovation and development.

[2] We refer here to the aircraft industry as the main object of observation. Space and satellite technology projects are nevertheless inspected as well, since the two branches of the aerospace industry are interconnected at the company level as well as at the thematic level, where spill-overs are commonplace.

has been mainly applied to theoretical network approaches. We extend the pure focus on the structure of networks with respect to the differentiation between invention (R&D collaboration network) and its commercialization (production network), which directly relates to current developments and challenges apparent in the aerospace industry, and broaden the analysis to other success dimensions.

This article is organized as follows. Section 2 provides a background overview, with section 2.1 giving a short characterization of the aerospace industry and its industrial and technological development in general, and section 2.2 explaining the data sources. Section 3 focuses on the question of whether the European aerospace R&D collaboration network follows underlying patterns of spatial success. Section 4 analyzes how the R&D network is shaped and questions whether its structure is of SBS type. Section 5 re-addresses the analytical goals of section 4 at the level of individual actors. Section 6 combines invention and production networks and poses the success condition of organizational ambidexterity. Section 7 concludes and assesses the potential for further research.

2. Data and background information

2.1 The European aerospace industry

In the 1970s, the landscape of the European aerospace industry changed dramatically with the appearance of the first European Programs, resulting in the creation of Airbus, a consortium of the leading European aerospace nations, in response to increasing project volumes and to the need, in the view of European politicians, to establish a counterbalance to the strong US aerospace industry. In the late 1980s, large international consortia were formed to spread costs and accumulate knowledge, focusing on cost efficiency, quality and performance. In the large civil aircraft sector, the competition between Airbus, as European champion, and Boeing, its American counterpart, increased.[3] In Europe, all involved nations tried to protect and foster participation of their firms, which led to an extremely fragmented industry structure, with numerous SMEs supplying the supranational enterprise of Airbus.[4] This leads to today’s industry structure, which can be seen as a collection of hierarchically organized pyramids (Acha et al. 2007, Lefebvre and Lefebvre 1998) whose apexes are leading companies such as Airbus and its first tiers, which supply engines, avionic and other complex product modules (Biggiero and Angelini 2014). In the 1990s and the new century, changes mainly are driven by crises, consolidation waves, industrial integration and a still-ongoing global reorganization. These developments correspond directly to the underlying data set and will be analyzed and set in relation to the achieved results.

The technological development constitutes only a few main changes which can be assigned to shifts in airframe and propulsion technology. While aircraft until the 1960s were primarily equipped with piston engines, jet engines have since been used on large civil aircrafts. This technology, as with many others, was developed and engineered for military use before and during WWII (Giampaolo 2006). Jet engine technology was considerably more complex and led to changes in the sector: consortia for jet engines were established, forming a unique sector within the aerospace industry, leading to a high fluctuation due to bankruptcy and entering companies (Frenken and Leydesdorff 2000, Nelson and Winter 1977, Dosi 1982). Today, the industry continues to rely on this technology, but several incremental innovations have been added resulting in extremely increased efficiency: compared to the 1960s about 70% less fuel is needed for the same range today. Since all aerospace OEMs operate near the technological frontier,

---

[3] Beside the two market leaders several other OEMs were present in the market at that time, e.g. McDonnell Douglas and Lockheed Martin.

[4] Not only Airbus as the manufacturer of aircraft, but also the defense and space entities were centralized under the European holding company EADS (a consortia of the national firms Aerospatiale Matra, DASA, CASA), founded in 1998/1999, and renamed and reorganized in 2013 to Airbus Group.

technological performance was not necessarily associated with market success (Bonaccorsi and Giuri 2001). Concerning aircraft design, with the exception of the Concorde, there have been no radical changes and no new trajectory concept is in sight. Engineers thus may be expected to further develop existing designs, improving the technology and the production system by, e.g., using new materials and intelligent solutions in aerodynamics, a rise in electrification in every part or segment of the aircraft, and lean production methods. In general, aircraft complexity and high market and financial uncertainty lead to the need for system integrators (Airbus) to maintain an established aircraft design, allowing components to be used in more than one aircraft model (Biggiero and Angelini 2014) as well as to further differentiate the value chain and establish risk and revenue sharing partnerships.

Therefore, the aerospace industry can be characterized as a technology intensive sector with a high R&D intensity[5], technological complexity, high and increasing development costs, long product life cycles, long break-even periods and small markets, problematic cash flow situations, high market entry barriers and a high governmental impact in form of ownership, regulation and as customer (Esposito and Raffa 2006, Alfonso-Gil 2007). The continuing innovation direction within the aerospace industry is sometimes redirected or restructured through radical changes in technology, market structure and institutional design (Braddon and Hartley 2007, Dussauge and Garette 1995, Jordan and Lowe 2004).

2.2 Data sources – CORDIS and Airbus

We use data on the European Framework Programs (FPs) on Research and Technological Development (RTD) to investigate the European aerospace R&D collaboration network. In the FPs, the European Union has funded numerous transnational, collaborative R&D projects. Project proposals are submitted by self-organized consortia (European Council 1998) and must include at least two independent legal entities established in different EU Member States or in an EU Member State and an associated State (CORDIS 1998). The proposal selection is based on several criteria including scientific excellence, added value for the European Community, and prospects for disseminating/exploiting results. The main objective has been to strengthen Europe’s scientific and technological capabilities.

Since their initiation in 1984, seven FPs have been launched. The only publicly available data source is the European Community Research and Development Information Service (CORDIS) projects database, which lists information on funded projects and project participations. However, many challenges exist in processing the raw data into a usable form, e.g. making organization names and other data consistent over time.

FP	FP2	FP3	FP4	FP5	FP6	FP7
Number of projects	390	714	241	196	255	217
Number of organizations	1.053	2.140	960	940	1.454	1.186
Number of participations	2.095	3.953	2.159	2.190	3.655	2.543
Mean number of participants per project	5,4	5,5	9,0	11,2	14,3	11,7

Table 1: Time dimension and general statistics on the funded aerospace R&D collaboration network

The core data set that we use is EUPRO database[6]. EUPRO comprises data on funded research projects of the EU FPs and all participating organizations. It contains systematic information on project objectives and achievements; indicators of project subjects, costs, and funding as well as contract type;

---

[5] Between 10% and 18% of revenue is re-invested in R&D.

[6] The EUPRO database is constructed and maintained by the AIT Innovation Systems Department by substantially standardizing raw data on EU FP research collaborations obtained from the CORDIS database (see Roediger-Schluga and Barber 2008).

and on the participating organizations including the full name, the full address and the type of the organization. From EUPRO, we identify aerospace-related projects as collaborative projects that have been assigned the standardized subject indices Aerospace Technology[7] or (standard only in FP7) Space & Satellite Research. We identify aerospace-related organizations as organizations taking part in at least one aerospace project (table 1).

Using the EUPRO database, we construct a network for each FP based on the collaborative aerospace projects. We take the network nodes to be the organizations participating in the projects, with links between nodes when the corresponding organizations participate in the project together. As organizations may co-participate in multiple projects, we assign weights to the links with a value equal to the number of mutual projects for the linked organizations.

The production network is proxied by the Airbus supplier list, which comprises all companies that are directly supplying goods and services to Airbus. This opens up the opportunity to compare production network and invention network on the actor and spatial level. The Airbus supplier lists are published monthly and made freely available on the Airbus homepage; we use the supplier data from March 2012. A drawback is that linkages between suppliers and suppliers of suppliers are not depicted.

3. Spatial prosperity or arbitrariness in the R&D collaboration network?

Over the decades of its existence, the aerospace industry has undergone changes caused by internationalization and economic concentration (Niosi and Zhegu 2010). Those changes directly impact regions: the aerospace presence in most regions has been radically downsized in favor of partners or suppliers in low-cost countries or strategic partners overseas. Therefore we expect the spatial distribution to show a strong concentration in a few regions supplemented with more sparsely participating regions. To explore this, we visualize the FP-derived aerospace networks in figure 1, aggregating the organization-based nodes and links to the level of NUTS-2 regions[8]. The size of a node shows the number of participants in the region, while the strength of a link between regions indicates the number of connections between organizations in the two regions—darker links correspond to more connections between regions within the respective FP.

---

[7] Projects in the FP4 subprogram FP4-BRITE/EURAM 3 originally were all assigned the Aerospace Technology subject index, but these were eliminated in a later revision of CORDIS. We have included these projects for consideration as aerospace projects. No projects in FP1 were assigned the Aerospace Technology subject index; we exclude FP1 from consideration.

[8] The NUTS (from the French for "nomenclature of territorial units for statistics") classification is a hierarchical system that segments EU economic territory for the production of regional statistics and socio-economic analysis. We consider the NUTS-2 regions located in the EU-25 member states, excluding Cyprus and Malta, and in analogous territorial units located in Norway and Switzerland. The collaboration data spans several revisions of NUTS classification; we used the 2010 revision throughout.

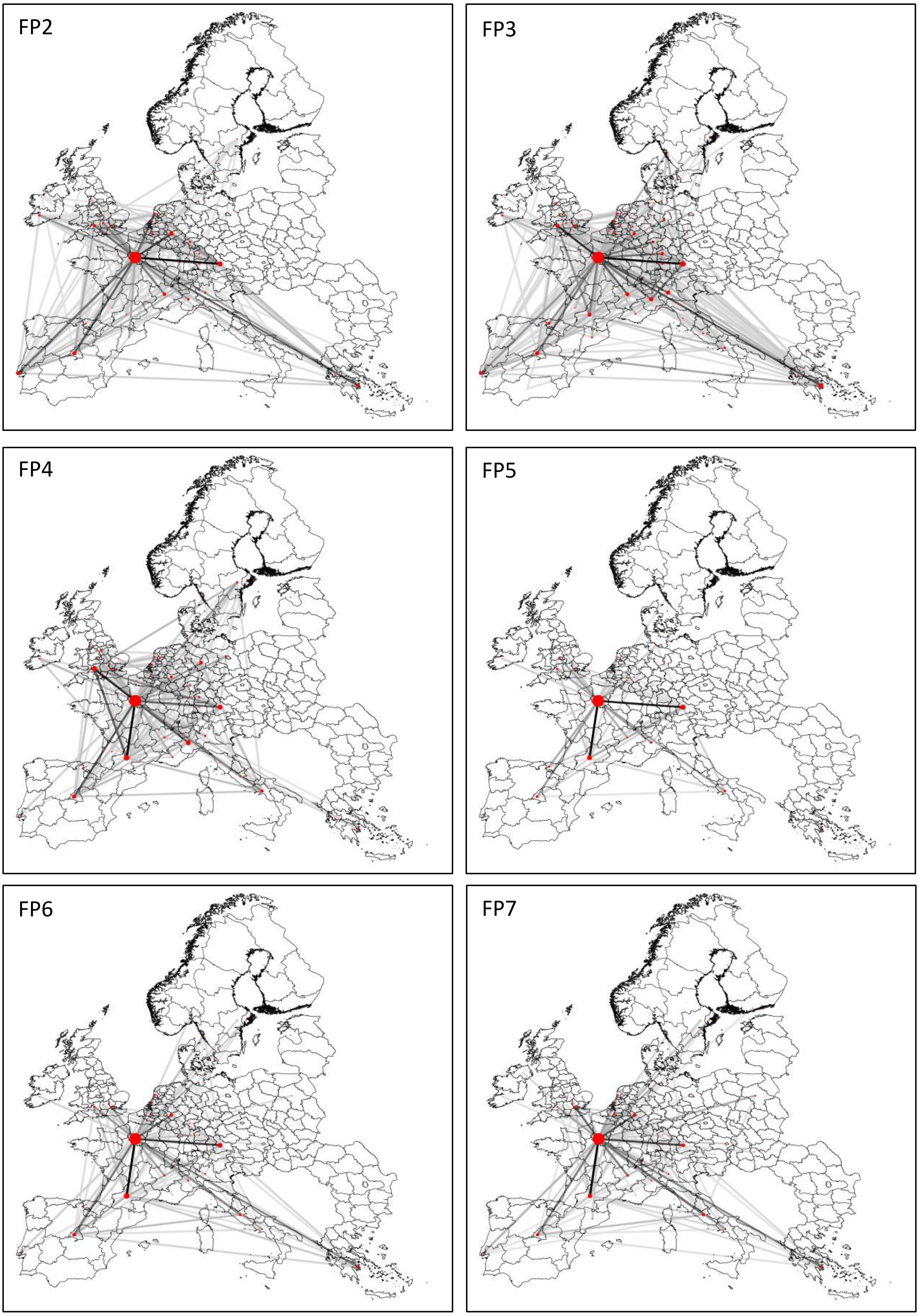

Figure 1: The European aerospace R&D collaboration network. The weakest links, corresponding to fewer than 10% of the connections in the strongest link in the same FP, are omitted.

Notable in figure 1 is that—especially in FP2 and FP3—a more uniform distribution over regions involved in the projects is visible compared to later FPs.[9] Infrequently participating regions are connected to the major regions, suggesting a spatial hub-structure in the European aerospace invention network. Over all FPs, Île-de-France can be seen as the overall center within the European R&D collaboration network. This is unsurprising; located in the region, in Paris, is Airbus (formerly EADS) headquarters, with its leading role in the European aerospace industry, in R&D as well as in production. Oberbayern in Germany also is very prominent. This is also unsurprising; besides the numerous suppliers, located in the region is the Airbus (EADS) innovation center in Ottobrunn (near Munich), as well as the Airbus helicopters location in Donauwörth. The rise in the prominence and importance of Toulouse and the Midi-Pyrénées region, where the Airbus production center or final assembly lines of most Airbus aircrafts is located, can be traced back to a shifting focus from product innovation to affordability, i.e. better, cheaper, and faster production to fulfill the increased orders.[10] Especially with the beginning of FP4, process-optimization related projects rose drastically[11], such as the optimization of the manufacturing process and the supply chain, non-destructive detection and repair systems, as well as quality and safety systems, leading to the increased prominence of the region.

Figure 2 depicts the cumulative distribution of the numbers of project participations in NUTS-2 regions for each FP. Visible is an overall growth of project participation over the FPs.[12] This can be seen by the expansion over all FP-curves, i.e. the number of project participations is increasing both in regions with many project participations and in regions with fewer project participations. While in FP2 only 10 regions take part in more than 380 projects, in FP6 about 100 regions reach this number. The threshold of participation by the 10 most active regions increased to more than 3300 in FP6. To relate these findings to the SBS hypothesis, we more closely examine which regions are responsible for the change in the distribution, with a particular focus on the right tail. We found that Île-de-France is the all-time leader, with the greatest number of participations in each FP, followed by several regions growing comparably. FP7 is an exception to the general trend of increasing numbers of participations; as the overall shape of the distribution is unaltered, we attribute the lowered participations to the incompleteness of the data on FP7.

Further we used a grouping mechanism to detect the development of the regions. We found that top-20 regions in FP2 remain among the most active, with the exceptions of Darmstadt (DE71) and Berkshire, Buckinghamshire and Oxfordshire (UKJ1), which decrease markedly in ranking. Positions 20 to 40 show an attenuated development compared to the top-20 regions. Most regions gain, especially Midi-Pyrénées (FR62) increases dramatically, as well as Campania (ITF3). Few regions decrease the number of project participations, e.g. UKD4. Positions 40 to 100 stay small with some minor exceptions, e.g. Toscana (ITE1) and Lazio (ITE4) increase project participation greatly in FP6 and FP7. Others gain

---

[9] Intra-regional linkages are not depicted within figure 1. This is only a minor drawback, as nearly no intra-regional collaboration exists – less than 3% of all collaborations are intra-regional, with nearly all in the center regions. This may reflect the participation premise for the European framework programs, where at least two partners from two different nations have to take part in a project. Additionally Guffarth and Barber (2013) found no thematic-spatial specialization pattern, i.e., there is no NUTS2 region with a superior knowledge base concerning one specific field of knowledge, at least in regions where a considerable number of projects have been operated.

[10] The optimization of the production process is today more relevant than ever before: e.g. Airbus has a backlog in producing aircraft that fills their order books through 2022.

[11] Nevertheless material science projects have been executed throughout all FPs and counted together are responsible objects or part objects in numerous projects. Satellite and space topics take a leading role in FP6 and FP7.

[12] Here and in the following FP7 is excluded, due to incomplete data.

positions in one FP and lose it in the next. The same holds for positions 100 -266, which stay very small, with no region notably changing its rank over time.

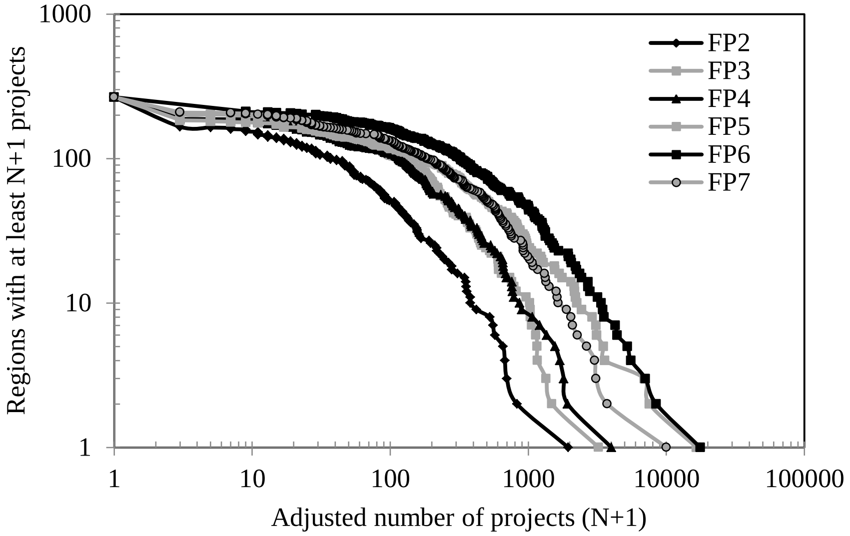

Figure 2: Cumulative distribution of project participations of NUTS-2 regions per FP. The number of projects N is shifted by one to allow inclusion of regions with no project participation on the logarithmic axis.

This indicates a tendency that success breeds success, as successful regions maintain their position and grow on a large scale, especially so for regions that have been strong in participating from the very beginning. One reason for such a development, besides the possibility that incumbent organizations grow over time, is that new actors are established. The new actors can be established through movement or, as Buenstorf and Klepper (2009) found, by successful incumbent firms tending to have more and better spin-offs. As most spin-offs locate close to their roots, geographic concentration of industries reinforces itself: these spin-offs become sources of renewed entrepreneurial activities, leading to a buildup of high-competence firms over time. This holds for industrial actors as well as for research organizations and scientific entities. There are several prominent examples within the European aerospace industry, e.g. CESA (Compania Espanola de Sistemas Aeronauticos SA) which is a spin-off of CASA and thereby Airbus, or Lavision which is a spin-off of the German Max-Planck Institute. Regions with a very low participation rate in the first FPs generally tend to stay small in later FPs. Nevertheless there are exceptions and bivalent developments, especially in regions that have been ranked in positions 20 to 40 in FP2.

We thus learn from the spatial development of the European aerospace R&D collaboration network that there are several hub regions (Île-de-France FR10, Oberbayern DE21, Cologne DEA2, MadridES30, Bristol UKK1, North Holland NL32, Piemonte ITC1 and Midi-Pyrénées FR62) successful from the inception of the FPs. The hub regions, through their actors, play a key role in connecting other participating regions. How the European R&D collaboration network is shaped on an organizational scale is analyzed in the next section.

4. Network indicators favoring success-breeds-success development

Building on the general information provided within section 2.2, we extend the characterization of the R&D collaboration network. First, we look at the changing composition of the FPs with respect to their affiliation. We found that the industrial share is nearly constant through FP5, ranging between 50-60%. Beginning with FP6, a drop to 45% can be observed and in FP7 only 38% of all FP participants are from the industry side of the sector. The lost share of industrial organization was nearly fully absorbed by the scientific entities (educational and research organizations), with an additional increase in governmental organizations and not specified participants. This development is closely related to the thematic development.[13] With the increase in satellite and space topics, also the demand for scientific knowledge increases (Broekel and Boschma 2010). Additionally, that satellite and space topics can seldom be commercialized might explain the fall in the industrial share.

Besides these compositional developments, table 2 summarizes some distinct metrics for characterizing the underlying networks. We used the main component in every FP to assure that path length measures are sensible and to avoid other measurement problems. The largest components include the great majority of the organizations making up the network; in each, there is a single important component, with no other sub-network of appreciable size or meaning. We show the FP7 main component network in figure 3.[14]

FP	FP2	FP3	FP4	FP5	FP6	FP7
Nodes	1339	2618	1208	1096	2172	1428
Nodes (main comp.)	1186	2059	1085	988	2141	1400
Edges	5722	13807	12083	27679	41811	23503
Edges (main comp.)	5429	12283	11713	27424	41754	23426
Density	0,008	0,006	0,020	0,056	0,018	0,024
Diameter	9	9	8	7	6	6
Mean path length	4,045	3,859	3,092	2,379	2,758	2,653
Average Clustering	0,838	0,839	0,860	0,870	0,873	0,867

Table 2: network metrics for the R&D collaboration network

---

[13] On a higher aggregation level three main topics are especially visible: reduction of environmental impact from emissions and noise, improved aircraft safety, and increased operational capacity and safety (Weber et al 2005).

[14] We determine the network layout using the Fruchterman-Reingold algorithm. The algorithm uses a physical analogy to determine the placement of network nodes. Nodes repel one another, like electrically charged particles, while links cause attraction, like springs. Solving for a static equilibrium in the resulting force equations results in a set of node positions where strongly interconnected sets of nodes are placed near one another.

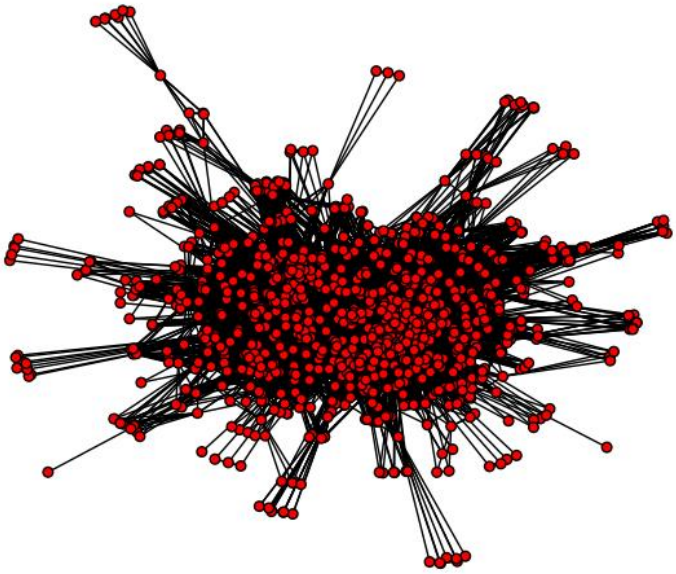

Figure 3: The main component of the FP7 European aerospace R&D collaboration network.

The density describes the overall coherence of a network which allows for implications concerning information and knowledge diffusion speed within the network (Hannemann and Riddle 2005). As reported in table 2 the density of the network is relatively low, especially within FP2 and FP3. The general low values are consistent with the network size – there is no possibility for each actor to establish and foster relationships to all other actors.[15] The low density in general indicates a kind of planned network, with non-random linking, making stability of the network as well as the knowledge flows highly dependent on the enabling actor (Schön and Pyka 2012).

The initially low density in FP2 and FP3 is consistent with the behavior in exploratory phases of industries, in which a growing number of firms join the network, bringing in their specialized knowledge and thereby increasing the variety of knowledge accessible for exploration activities (Pyka 2011). The higher density in FP4 and FP5 is consistent with exploitation stages of an industry, where the network has matured to some extent, with less growth in the number of actors but more frequent linkages among the actors; knowledge transfers among actors has strengthened, increasing the efficiency of innovation processes within a well-known knowledge field in the exploitation phase (Pyka 2011). The density again drops after FP5; this may be attributable to the new presence of space and satellite topics producing a new exploratory phase with more organizations joining the network, with new links forged between existing organizations and new participants and also among existing organizations (Breschi and Cusmano 2004). Further an explanation for FP5 and FP6 density decrease might be found in the maturity position within the industry life cycle, as new product developments are rare[16] and clear focus on the technological challenges are in sight (Abernathy and Utterback 1978, Utterback 1994, Klepper 1996 and 1997), which decreases the density of firms in the respective industry (Schön and Pyka 2012).

Average path length gives information about how rapidly an arbitrary vertex can be reached from any other vertex. Many real social networks have a short characteristic path length, giving rise to the small world effect (Roediger-Schluga and Barber 2008). Short path lengths are associated with rapid

---

[15] See Scott (1994. For a general explanation for the rareness of completely linked networks see Mayhew and Levinger (1976).

[16] Even if in the literature to complex products (Hobday 1998) a general movement of those industries is seen as an seldom happening, the aerospace industry is today in a kind of typical maturity phase where production is in focus and no new product developments are in sight for the next years or even decades.

knowledge diffusion and the possibility to exchange even complex and tacit knowledge. Thus, for knowledge exchange, small world network are seen as highly efficient in their structure (Schön and Pyka 2012) with regard to key functions of R&D collaboration networks. However, short path lengths are not sufficient for learning (Roediger-Schluga and Barber 2008)—e.g., completely identical organizations cannot learn from each other and therefore different knowledge is needed while at the same time sufficiently similarity is needed to communicate and appropriate the new knowledge (Teece 1986 and Levin et al 1987). The aerospace R&D network is characterized by short paths. During FP2 and FP3 we observe higher path lengths (3.4 and 3.5) compared to FP4 until FP7, where it decreases from 2.88 in FP4 to 2.31 in FP5, with slight increase in FP6 (2.36) and FP7 (2.46). During the early FPs, new network parts docked to the main component, producing a more frayed network with longer paths. The network gets more closely integrated in FP4 through FP7, resulting in the mentioned decrease in average path length.

Besides the short average path length, the clustering coefficient is also relatively high in typical real-world networks (Watts and Strogatz 1998). Clustering means that the network possesses local clusters of nodes in which a higher than average number of nodes are connected to one another. The average clustering coefficient is extremely high with an average value of 85.1%. Moreover, there is a slight increase in the clustering coefficient of the organization networks from FP2 to FP5, suggesting that the integration between collaborating organizations has increased over time. The above arguments concerning the newly added space category and the recent developments within the aircraft manufacturing industry can be reiterated as a possible explanation for the lower clustering coefficient in FP6 and FP7.Another aspect of the network structure can be explored using the degrees of the nodes. The degree of a network node is the number of connections it has to other nodes, corresponding in the FP aerospace networks to the number of collaborative partners. The cumulative degree distributions for the aerospace networks are shown in Figure 4. As seen in many large real-world networks (see, e.g., Newman 2003), the distributions are strongly right-skewed with a heavy tail. The majority of aerospace actors thus have below-average degrees, but a small number of actors have degrees that are orders of magnitude above the average. These hubs are highly connected nodes that play key roles in defining the global connectivity of the network and may dramatically influence how the network functions; the hubs thus have properties we would expect of the stable core of dominant organizations in a Schumpeter Mark II sector.

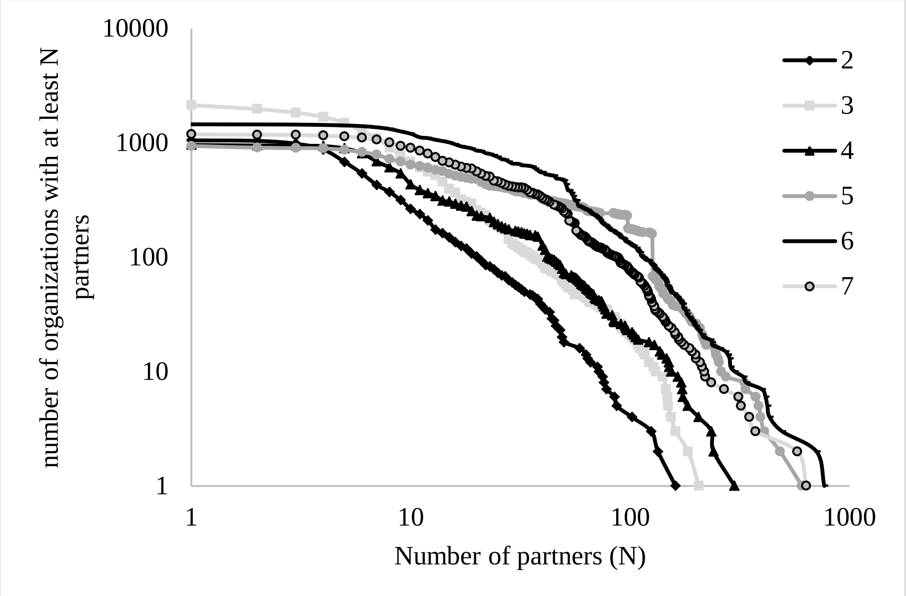

Figure 4: Cumulative distribution of the number of partners

In principle, high-degree nodes could result from organizations taking part in relatively few projects that have many participants. We address this question in Figure 5, comparing the number of participations to the number of partners — i.e., the degree — for each organization taking part in an FP7 aerospace project. We see a strong correlation between the degree of the nodes and the activity of the corresponding organization. Similar correlations are present in other FPs (not shown).

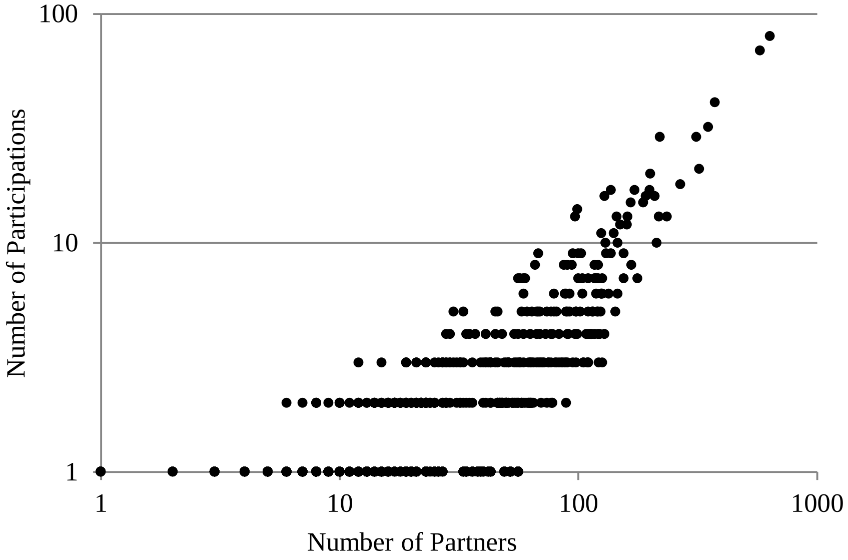

Figure 5: Comparison of the number of partners with the number of participations in FP7

Centralities depict another category of signals for analyzing the network in detail. Centralities are prominent actor-related measures that can be used to assess power and influence. The simplest centrality is degree centrality, which is just a normalized version of the degree distribution that we have already considered. Despite the insights gained from analysis of the degree distribution, it treats all links as equally important. But connections might not be the same. For example, connections to other actors who are themselves well connected may be expected to provide actors with more influence than links to poorly connected actors, leading to the concept of eigenvector centrality. For eigenvector centrality, each vertex is assigned a centrality that depends both on the number and the quality of its connections by examining all nodes in parallel and recursively assigning centrality weights that correspond to the average centrality of all neighbors.

Other centralities arise by considering whether an actor could occupy a strategic network position allowing it to better access the information flow in the network. These considerations lead to the closeness centrality. Closeness centrality measures the proximity of an actor to all other actors in the network. The closeness centrality of the corresponding vertex is defined as the inverse of the mean geodesic distance[17] from the vertex to every other vertex in a connected graph (Wassermann and Faust 1994).Greater closeness centralities indicates a greater ability for the actor to receive or distribute information (Wassermann and Faust 1994).

Based on the same logic as closeness centrality, betweenness centrality (Freeman 1977) can be defined as the fraction of geodesic paths between any pair of nodes on which it lies. It is a measure of control, as actors that lie on many shortest paths can exert considerable control and act as gatekeepers, intermediaries, liaison and bridges. Actors with a high betweenness centrality do not necessarily have

---

[17] The length of a path between two network nodes is the number of steps taken to reach one vertex from the other. The geodesic distance is the length of the shortest path between the nodes.

to maintain many direct links themselves and networks that show a high level of betweenness are more vulnerable to a disruption of information flows through strategic behavior or the retreat of these key actors (Schön and Pyka 2012).

Figure 4 compares the discussed centralities within the European aerospace R&D collaboration network for FP7; the results for the other FPs are comparable. We compare the degree centrality to each of the three other centralities: the centralities are strongly correlated, especially so for the most central organizations. Therefore we conclude that organizations that are powerful in one way are going to be powerful in the other ways.

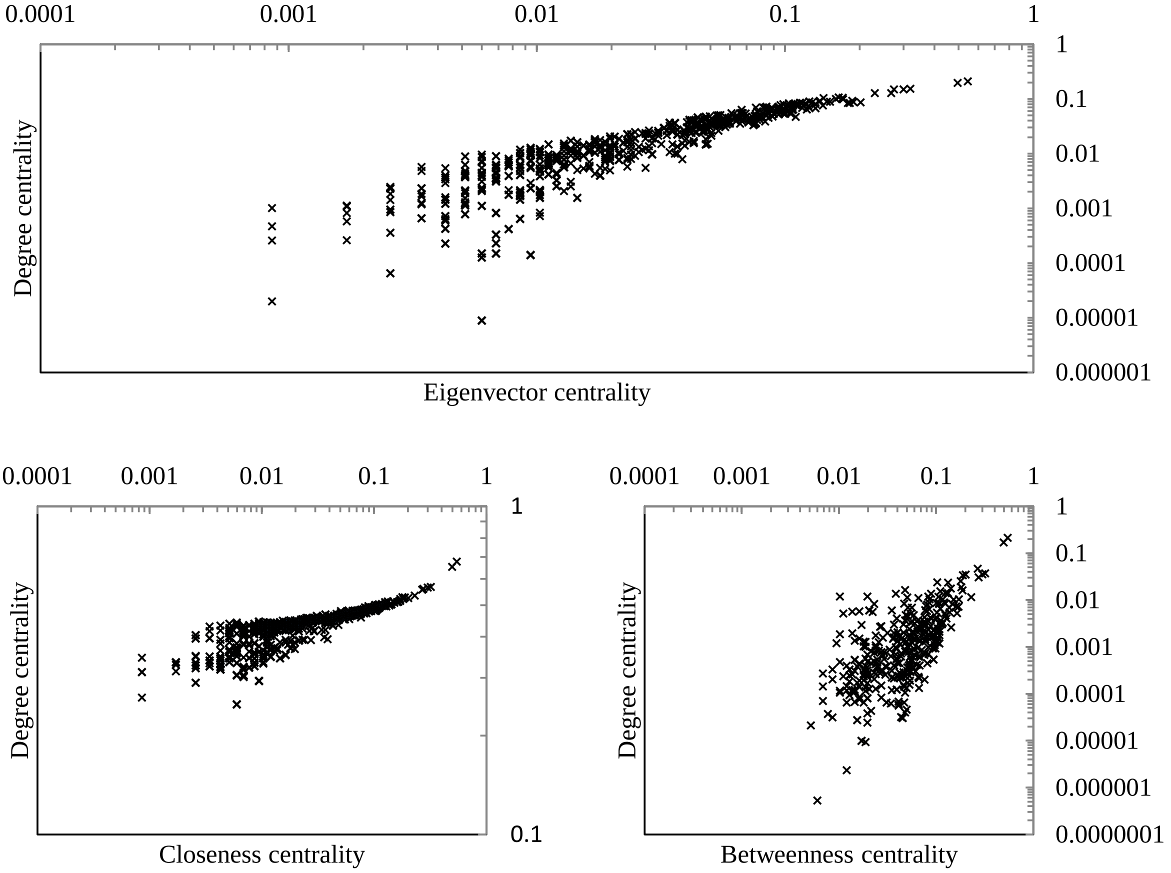

Figure 6: comparison of degree centrality with closeness-, eigenvector- and betweenness centrality

Hence, we introduced a unified centrality measure as a one-dimensional aggregate of the group of centralities. We do this using principal component analysis, taking the unified centrality as the projection of the four computed centralities onto the first principal component. The unified centrality is thus the one-dimensional centrality that maximally accounts for the variability in the centrality data. Figure 6 shows the distribution of the unified centrality measure for all organizations over all FPs. All unified centrality distributions are highly skewed. In figure 6 and 7, notable is the presence of a small set of high-centrality organizations combined with a large number of actors having lower centrality values. This indicates a great deal of heterogeneity among the network participants. Combined with the insight that the unified centrality measures the importance and power of an actor, we conclude that within the European aerospace R&D collaboration network, power in multiple dimensions is strongly concentrated in a small set of actors.

The concentration of the unified centrality, and the correlated centralities that permit its definition, lends support to the SBS hypothesis. The high-degree hub organizations play a key role in shaping the structure of the network through their many collaborative partnerships and do so in a way that strategically positions themselves with greater ability to access and regulate knowledge flows. But only successful organizations have the ability to form so many collaborative ties, with success thus breeding further success in the European aerospace R&D collaboration network.

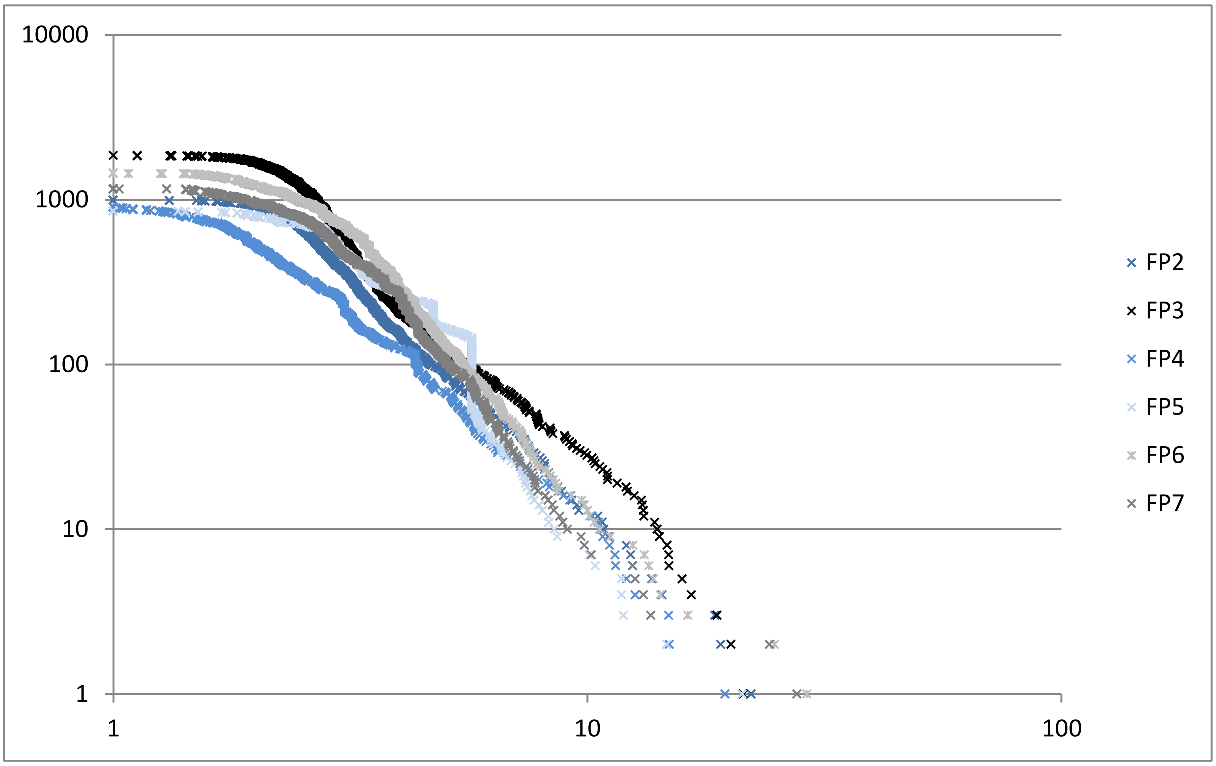

Figure 7: Distribution of the unified centrality measure (N+minN+1)

In this light we are motivated to ask what these central organizations are, how they change over time, and what their roles are within the network. These questions relating to the status of the organizations within the network are answered in the next section, helping us to answer the question whether success breeds success on an individual or actor-based level.

5. Success breeds success on an individual actor base

Thus far, we have seen that the European aerospace R&D collaboration network has small world features and large hubs. Different measures of organizational prominence — number of project participations, number of collaborative partners, measures of centrality — are correlated, indicating that the hubs are important in several dimensions. But what are these prominent organizations and how did they develop over time?

We select a set of prominent organizations for more specific consideration based on the total number of aerospace projects in which the organizations participated[18] over the course of FP2-FP7. We focus on the ten most active organizations, which should correspond to the expected stable core of the aerospace sector. In Figure 8, we show the development of the unified centrality for the core organizations, with

---

[18] Alternatively, the degree or centrality of nodes in the network for a particular FP could be used. As these quantities are correlated with the number of project participations, this would produce a substantially similar set of organizations, with only minor variation in the organizations considered.

the centralities of the other organizations included for comparison. The core organizations show certain stability, being among the most central organizations in all FPs. This stability is not, however, absolute: other organizations may be more central in specific FPs, while the core organizations change relative positions over the course of the FPs. The core organizations are thus consistently positioned so as to strongly shape the aerospace R&D network in Europe—actors in a central position face fewer constraints and have more opportunities because of a better bargaining position and greater influence (Schön and Pyka 2012). Such actors can foster or hamper the effectiveness of an R&D collaboration network in that they connect different knowledge fields or exclude other members from accessing information (Schön and Pyka 2012).

Striking in the development of the centralities are the roles of Airbus and the Helmholtz-Gemeinschaft (HHG). They are the two most central organizations, consistent with what we might expect from their prominent roles in European aerospace; Airbus is central throughout the FPs, while HHG shows a dramatic rise in the centrality in later FPs to eventually exceed that of Airbus in FP7. Airbus, including the formerly EADS group, is the leading manufacturer of aircraft in Europe and nearly all projects are of relevance for them. The HHG is the leading German government research organization with an aerospace relevance with its subentity the German aeronautics and space research center (Deutsches Zentrum für Luft- und Raumfahrt - DLR). Their switching roles is consistent with thematic developments, as in FP6 for the first time satellite and space topics emerge, representing a very high share of total projects. Therefore scientific knowledge is more requested than in the precursor projects, leading to the more central positioning of HHG over Airbus in FP7.

Further showing the dependence of the centrality ranking on the thematic development is that both engine manufacturers, Rolls-Royce and Snecma, develop in a similar fashion. From mid-range positioning in the core organizations, both engine manufacturers then decline to be ranked 9th and 10th of the core organizations in FP6 and FP7.

As the unified centrality combines distinct centrality measures, the increasingly central positions of HHG and other research organizations point to network structure simultaneously changing on several fronts — the increasing scientific focus leads not just to more projects relevant for organizations with a scientific focus, but also leads to their acting as brokers between increasing numbers of partners that are themselves important players. We interpret this as the new projects bringing in many new actors that are linked mostly with one another. The core organizations, especially Airbus and HHG, appear to co-ordinate the major part of knowledge flows through the European aerospace network, connecting coherent subnetworks; the changing centrality indicates reconfiguration of these subnetworks. In the European aerospace R&D collaboration network, the core organizations seem to be able to connect different technology fields, which may lead through the recombination of knowledge groups to innovation.

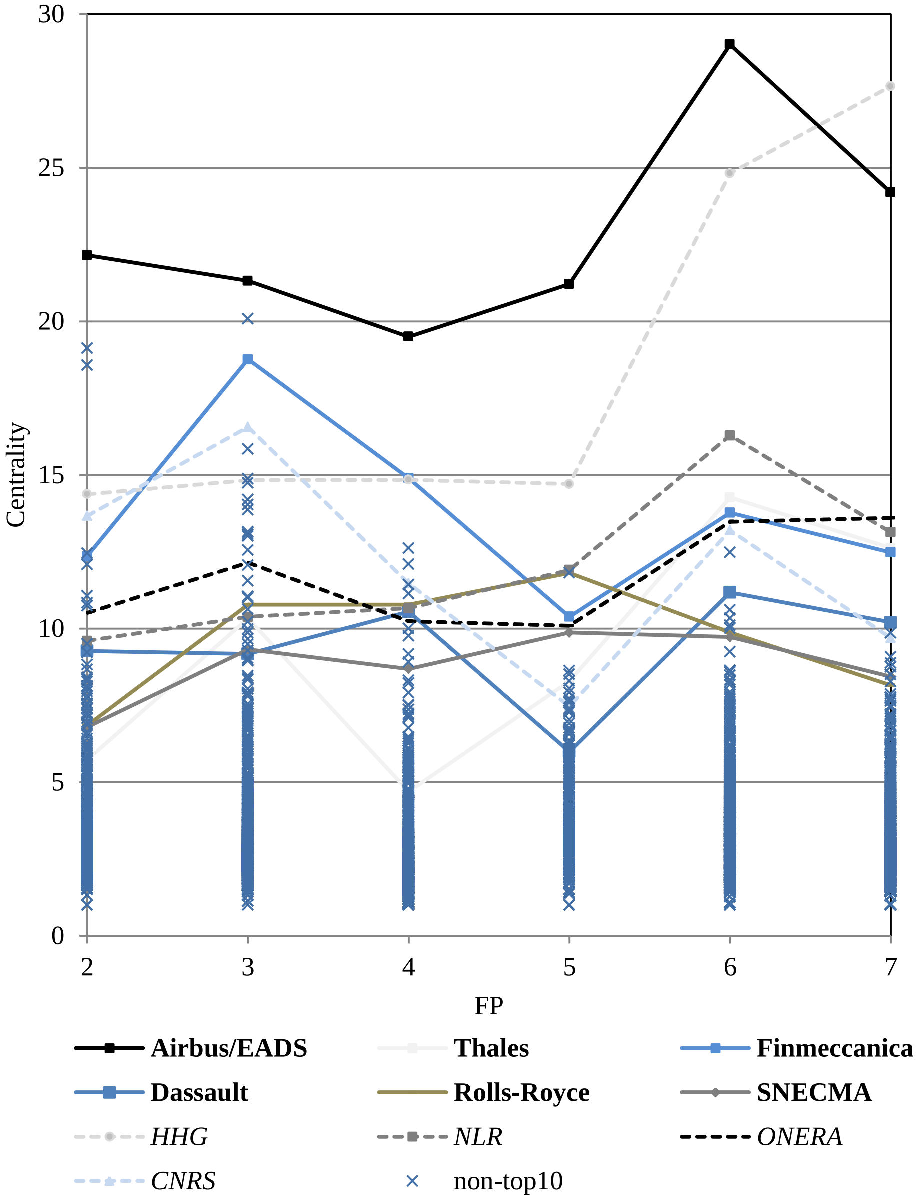

Figure 8: Unified centrality measures for the core organizations

The centrality analysis makes clear the importance of the core organizations. Also of interest is whether the core organizations are strongly or weakly connected to the rest of the network. Weak ties can be interpreted as giving an organization the possibility to see the big picture and acquire new information from outside the organization.[19] We find that only a few organizations are strong recurring partners of the core organization — rather core organizations are strong, recurring partners of one another. Nevertheless, the core organizations do have many weak ties (figure 9), consistent with their being hubs, and do have strategically outstanding positions in the European aerospace R&D collaboration network. The core organizations are thus well suited with direct links or strong ties, which support the exchange of complex knowledge essential to working on projects, but also are well endowed with weak ties, which

---

[19] Weak ties are defined by Granovetter (1973) in a social network context.

may be more beneficial for searching for information (Hansen 1999). To assess the tie strengths, we turn to edge weights calculated as the number of projects in which the linked pair of organizations both participates. In figure 9 the distribution of weights for links incident on any of the core organizations, which account for many[20] of the links in the networks, is depicted. There is a wide variation in the weights, with both very strong weights and very many weak weights. This illustrates the presence of weak ties and reflects the possibility of accessing sources of knowledge that are not regularly used.

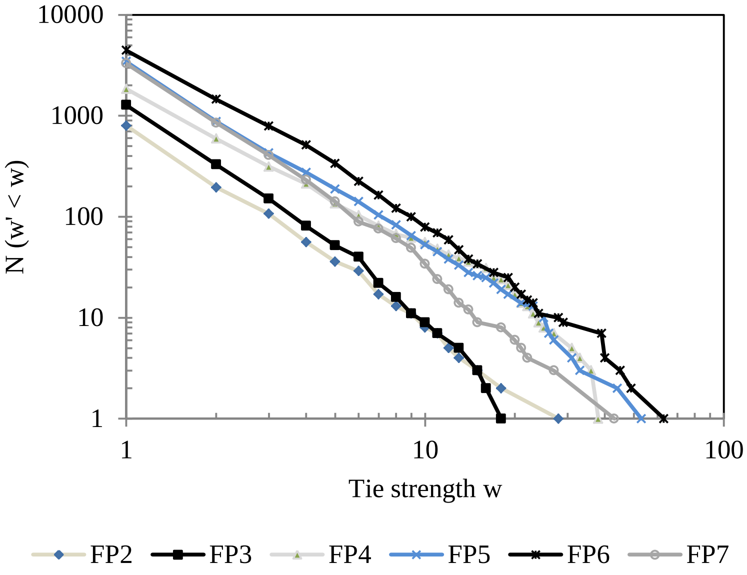

Figure 9: Distribution of weights for links incident on any of the core organizations

Since the core organizations are strong recurring partners of one another, we consider also what sorts of interconnections are present within the core and how stable the core of the network is. The networks in figure 10 are determined by keeping links between organizations that have multiple co-participations, excluding links below some weight threshold and dropping organizations that are not thereby disconnected from any others.

---

[20] The percentage of links incident on the core organizations ranges from a low of 10% in FP3 to a high of 19% in FP4.

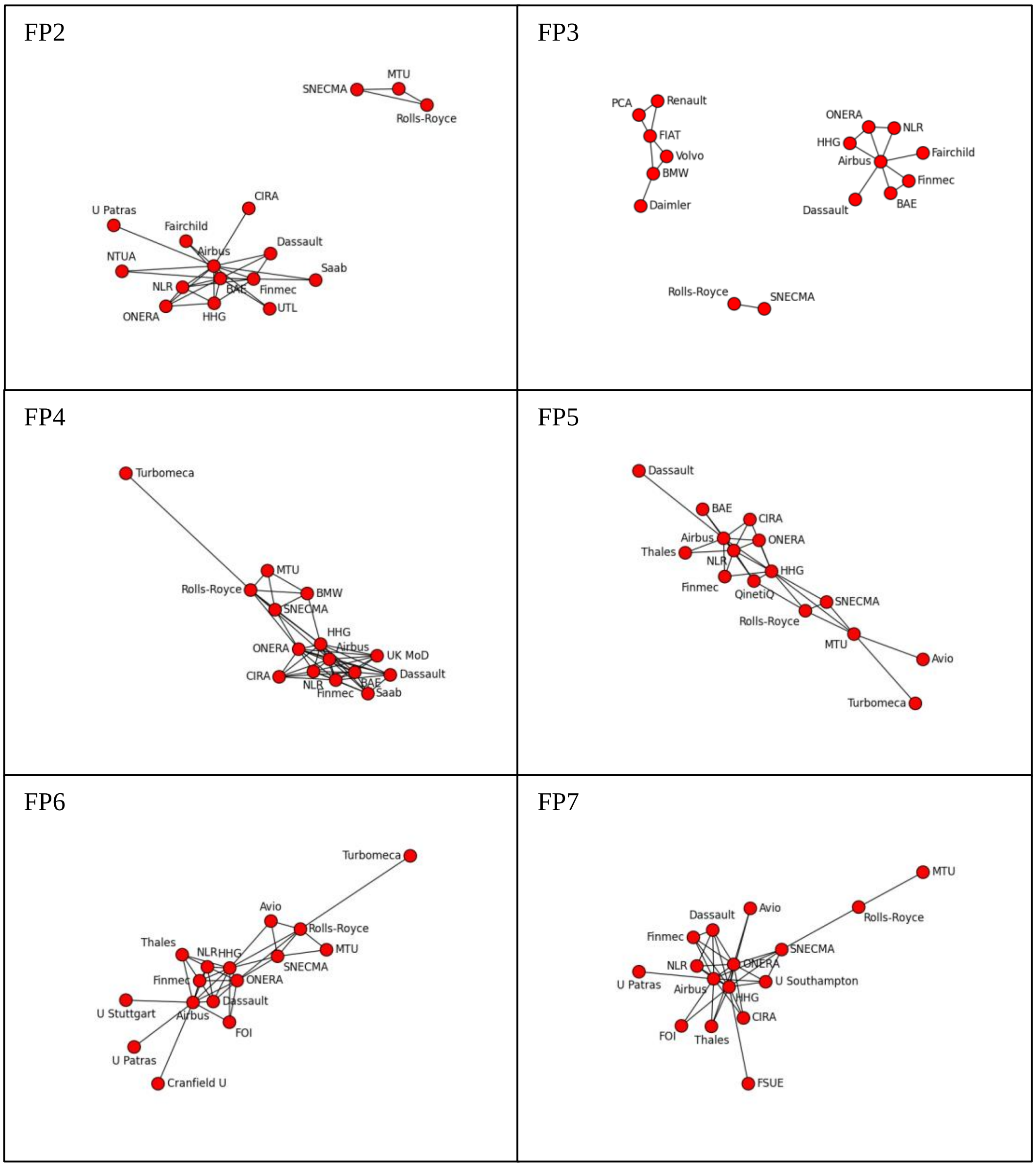

Figure 10: Cores of the European aerospace R&D collaboration network for each FP

We chose thresholds to produce at least15 organizations in the core. In each FP network, we see a core dominated by Airbus, with other key organizations connected, mostly showing the core organizations. There is a clear tendency that the network core is stable. Additionally thematic subcores are visible, especially a differentiation between airframe related companies, engine related firms, and within FP3 a special automotive subcore is seen.

Beside these cores, network participation in the FPs is fluid over time, with organizations entering, withdrawing and returning during different FPs (see table 4). Table 3 shows that there is continuity in the set of actors and thereby indicating that success breeds success. Nevertheless, it is apparent that many organizations enter and leave the programs from one FP to the next. This is another indicator for a fragmented industry structure with many organizations involved specifically in distinct subject areas. Additionally, this directly indicates the mentioned classification of aerospace as a Schumpeter Mark II sector, characterized by creative accumulation and by the dominance of a stable core of a few large organizations, with limited permanent entry. The core organizations seem to use specific small organizations or other specialist actors to enhance their knowledge and thereby consolidate their positions.

FP-n	FP-(n+1)	Leaving	Continuing	Entering
2	3	580	473	1.667
3	4	1.765	375	585
4	5	709	251	689
5	6	600	340	1.114
6	7	958	496	690

Table 3: organization continuity over FPs

Notable is that in sum only 107 organizations—2% of participating organizations—take part in all FPs. Those 107 organizations are composed out of only 20 industry organization and therefore 87 actors entirely composed out of scientific and research organizations, such as universities and research institutes. Table 4 demonstrates continuity in the collaborations, also supporting the SBS hypothesis. Participation in the FPs is fluid over time, with organizations entering, withdrawing, and returning during different FPs. Despite these changes, repeated collaborations are observed. In table 4, we show the repeated co-participations between FPs. Entries in the table show the number of distinct pairs of organizations present in an FP that recur in a specific later FP (e.g., 1260 pairs of organizations that collaborated in FP4 again took part in projects together in FP5) or any later FP. Diagonal elements show how many distinct pairs of collaborating organizations are present in each FP. To establish a baseline expectation of repeated co-participation, we include the expected numbers of repeated co-participations in randomized versions of the aerospace collaboration networks, based on randomly switching organizations between projects; the values shown are averaged over 1000 instances of the randomized networks. By comparing to the expected values, we infer the presence of stable, repeated collaborations. Within each FP, the number of distinct co-participations is lower than would be expected if organizations were randomly assigned to projects, indicating that numerous collaborators take part in multiple projects together. In contrast, the number of co-participations repeating between FPs is higher than would be expected from the randomized networks, revealing the presence of collaborations that are stable over time.

FP	FP 2	FP 3	FP 4	FP 5	FP 6	FP 7	Any later FP
2	**5722**	**422**	**256**	**185**	**57**	**104**	**728**
2 expected	6305.2	53.4	83.7	86.7	41864	41.9	220.3
3		**13807**	**865**	**488**	**126**	**187**	**1169**
3 expected		14541.3	148.4	142.8	41837	56.8	296.8
4			**12083**	**1260**	**180**	**269**	**1405**
4 expected			13122.5	691.7	77.0	164.7	796.3
5				**27679**	**518**	**689**	**1011**
5 expected				28526.5	272.1	467.1	670.4
6					**41811**	**1014**	**1014**
6 expected					43737.0	366.6	366.6
7						**23503**	
7 expected						24706.8	

Table 4: Development of repeated co-participation over the FPs

Further, the repeated collaborations are seen to have some stability over time. In general, the sum of the FP-specific repeated collaborations is greater than the number of distinct collaborations repeated in any later FP. Thus, there must be numerous organizational pairs that re-occur across multiple FPs, indicating the presence of stable collaborative partnerships.

Nevertheless there are many one-time (about 78%) and two-time participants (about 12%) across the FPs. By inspecting those groups Guffarth and Barber (2013) found that these groups are mostly composed out of SME and industry-external organizations. Therefore in light of the SBS hypothesis, due to SMEs capacity constraints and thematic limitations, we must consider a different success measure than participation for SMEs. This can be, e.g., to be absorbed into larger players or building durable relations. In general, SMEs play an important role in preserving the power of MNCs within the network, since the large firms employ small firms as a window on new technology (e.g., Roberts and Berry 1985), while larger firms offer SMEs experience in volume manufacturing in exchange (Doz 1988). For the aerospace industry, there are several examples of successful SME-MNC interaction. An example for a successful acquisition is Erwin Kayser-Threde GmbH, which was established in Germany in 1967 and is specialized in earth observation, optical systems and space technologies. In 2007, OHB AG acquired Erwin Kayser-Threde GmbH, constituting a success story. Examples for successful joint ventures are United Monolithic Semiconductors SAS and Intespace SA, which are joint ventures of EADS and Thales focusing on aerospace and defense technology.

Therefore success of SMEs is co-opted into the success of MNCs, which is consistent with a core of successful organizations which is not invaded. Assuming that every organization wants to take part in FP projects, SMEs in particular discover conditions that prohibit this success. On the one hand, this may arise from the low breadth of their knowledge base – they mostly are specialists. On the other hand, it may arise from capacity constraints (financially and man power). We conclude that the 2% of participants active in all FPs secure their position and have established a success platform through which they are able to identify and develop new topics.

6. Organizational ambidexterity as prerequisite for success

Besides the ability to invent as a success factor for industrial actors, the ability to commercialize their inventions is a success factor of outstanding importance, especially for long-term success. Innovative success yields profits that can be reinvested in R&D and thereby increasing the probability to innovate again (Malerba 2004). Therefore organizations should possess a kind of ambidexterity that enables them to cope with not only current production, but also future needs that depend on invention and R&D collaboration (March 1991, Levinthal and March 1993, Henderson and Clark 1990 and Gupta et al. 2006). In this light, success needs to be evaluated taking into consideration long-run success factors. In particular, the evaluation should take into account the focus on either exploration (in our context, participation in R&D collaboration networks) or exploitation (here the solely production related topics) may lead to technological, knowledge–related, and organizational lock-ins, turning the short-term success factors into long-term drawbacks and leading to a success breeding failure. We proceed from the assumption that only those organizations (and therefore regions, as the sum of all organization in them) that are able to be ambidextrous can be successful in the long run.

To get an impression on how the aerospace industry is designed with respect to the ambidexterity challenge, we compare in this section the innovation network (FP7) and the production network (direct suppliers of Airbus in 2012). For the analysis of the production network, we use data on companies directly supplying products and services to Airbus. The Airbus supplier lists are published monthly and made freely available on the Airbus web site.[21]

---

[21] A drawback is that linkages between suppliers and suppliers of suppliers are not depicted. Nevertheless, it suffices for comparing the members of the production network with those of the innovation network.

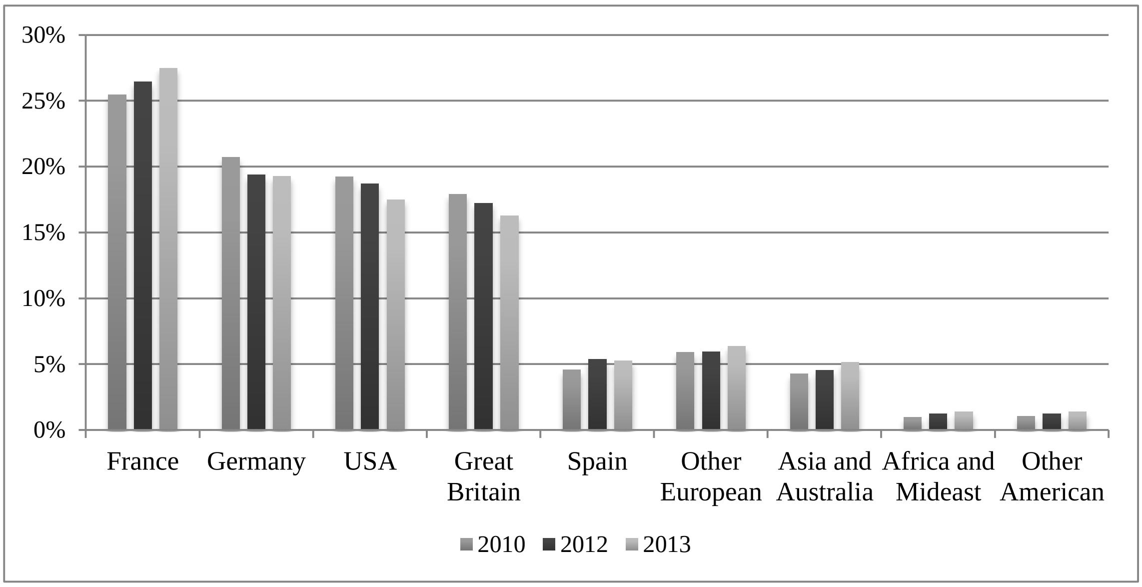

Figure 11: Airbus supplier 2010-2013

Figure 11 gives an impression of the Airbus supplier network. There are in general five countries — France, Germany, the USA, Great Britain and Spain — that provide about 88% of the overall number of Airbus suppliers. Together with the rest of Europe, they account for nearly 94% of all suppliers. Striking is the development of the shares even in this short time frame. France is the only country of the “big four” with increasing numbers of suppliers from 2010 to 2013, while Germany, the USA and Great Britain have decreasing numbers. Other European nations, as well as Asian, African, and North and South American countries, have increasing Airbus supplier numbers.

This distribution is consistent with Airbus strategy and history (Rhode 2012 and Richter 2014). The USA is historically strong, as Tier-1 suppliers are located there, providing their goods and services all over the world including Europe and Airbus (ECORYS 2009). The other four main countries reflect the Airbus member and owner countries, where a proportional representation of suppliers was wanted by the respective government. The increasing numbers of Asian, African and other North and South American countries is twofold. On the one hand, Airbus needs to spread risk, in the form of currency assurances, as well as seeking low-cost countries to source cheaper parts and components (Mazaud and Lagasse 2007). On the other hand, this development is market driven, as countries (especially China) seek to import knowledge and know-how instead of buying aircraft (certainly the booming region in aircraft demand is Asia), driving globalization and the spread of aircraft manufacturing knowledge.

The geographical distribution of the European Airbus suppliers is depicted in figure 12. Figure 12A shows the regional distribution of the FP7 R&D collaboration network members and 12B the Airbus suppliers in 2012. To provide a more equitable comparison, we exclude all actors from the R&D network who are solely dedicated to satellite and space technologies, as we suppose that these actors are of less direct relevance to the Airbus aircraft manufacturing entity. Nevertheless, we must be careful in generalizing from comparative numbers, as our maps only depict the number of actors and supplier per region, with no provision for, e.g., the economic value created.

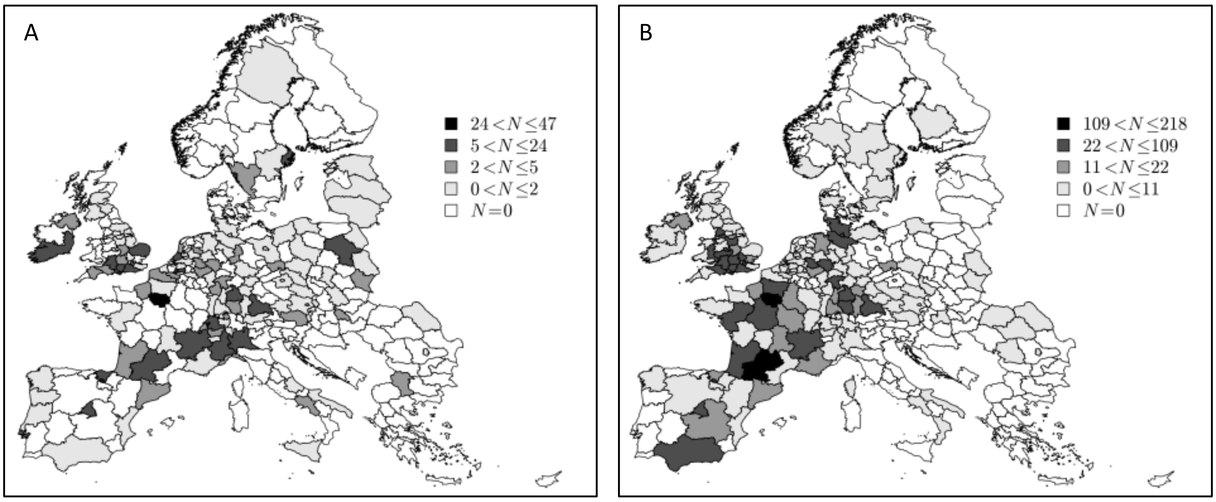

Figure 12: A. FP7 R&D collaboration network. B. Airbus suppliers 2012. N is the number of actors within the appropriate NUTS-2 region.

We visualize the regional actors at the NUTS-2 level; shading map regions to show the number of actors present (Fig 12). For each map, one or two regions have a markedly greater number of actors than the other regions; we treat these as a distinct class of key regions. We classify all other regions into having a high, medium, or low number of actors. As the number of actors varies widely across regions, with many regions having very few actors, we take the high-participant group to be those regions with a number of actors exceeding 10% of the maximum number of actors in a key region; the medium-participant group as those with a number of actors between 5% and 10% of the maximum; and the low participant group as those with a number of actors at most 5% of the maximum.

In Figure 12B, an often mentioned and cited characteristic of the aerospace industry is clearly visible: production networks are usually organized in geographical clusters (Eriksson 2000, Niosi and Zhegu 2005, Beaudry 2001, Jackson 2004 and Lublinsky 2003). Usually, a system integrator and many suppliers, many of them SMEs, compose a geographically localized value chain. In Europe we can see in figure 12B that there are seven center regions in the production network – (1) Midi-Pyrénées (FR62) and its neighbor Rhône-Alpes (FR71); (2) Île-de-France (FR10); (3) Hamburg (DE60); (4) the southern German regions Oberbayern, Stuttgart, and Tübingen; (5) South West England; (6) North West England, with Greater Manchester and Lancashire; (7) and the Spanish regions Madrid and Andalusia. In each cluster there is an Airbus production location around which the suppliers agglomerate.

In comparison to the R&D collaboration network, we see that the regional centers in the production network are all represented in the R&D network. Nevertheless there are differences. The two French clusters, the southern German cluster, and the cluster centered in South West England are equally strong in both networks, but Hamburg (DE60) is by far more strongly represented in the production network. Notable is that the regions neighboring Île-de-France are especially strong in the production network, but not represented in the R&D network. The opposite holds for the Italian regions Piemonte (ITC1), Lombardia (ITC4), and Lazio (ITE4) which are strongly represented in the R&D network, but are nearly absent in the production network; this allows a historical interpretation, as Italy is more connected to the American Boeing company than to Airbus, so that their productive capacities are more concentrated on the overseas system integrator. Similarly, the Baltic countries and northwest England are notably more prominent in the R&D network than the production network.

We see that regions that participate in both networks generally do have more actors within a region, supporting the SBS hypothesis. This highlights the need for a regional mixture of organizations taking in part in research as well as production related tasks.

To cope with recent challenges on the production side, especially SMEs and actors with restricted cost and capacity capabilities will face the risk of participating even less on the R&D side. This may be a successful strategy for the short term, but will lead to serious problems in the long run, especially if R&D is additionally neglected outside of the funded collaboration networks.

7. Conclusion

Using data on the European Framework Programmes and on Airbus suppliers, we analyzed the European aerospace industry with the focus on the success-breeds-success hypothesis at four levels: the spatial structure of the European aerospace R&D collaboration network, its large scale structure, an individual actor level, and with respect to a combination of the Airbus invention and production network. The resulting insights support the findings of Phillips (1971), who found that — especially in industries with complex products, where products are simultaneously improved on multiple dimensions and introduced in the form of new models (Klepper 1997) — product R&D could play the same role as process R&D in Klepper's model. Thereby, a SBS process is supported over time, leading to greater concentration in such industries.

On a spatial level, a clear indication favoring SBS is visible, as successful regions maintain their position and grow on a large scale, especially so for regions that have been strong in participating from the earliest FPs. Additionally, we learn from the spatial development that there are several hub regions, successful from the inception of the FPs, which, through their actors, play a key role in connecting other participation regions. A hub structure has been also detected in the structure of the European aerospace R&D collaboration network, where the high-degree hub organizations play a key role in shaping the structure of the network through their many collaborative partnerships. Based on an analysis of several centrality measures, we see that they do so in a way that strategically positions themselves with greater ability to access and regulate knowledge flows. This has been confirmed with the insight that the unified centrality, measuring the importance and power of an actor in multiple dimensions, is strongly concentrated in a small set of actors. We therefore conclude that the hubs have properties we would expect of the stable core of dominant organizations in a Schumpeter Mark II sector. As only successful organizations have the ability to form so many ties, success thus breeds success in the European aerospace R&D collaboration network. Based on these insights, we were motivated to investigate what these central organizations are, how they change over time, and what their roles are within the network. The importance of the core organizations is further supported by the analysis of tie strengths, where we observe that the core organizations are additionally highly connected to the rest of the network, thereby confirming their outstanding positions in the European aerospace R&D collaboration network as being able to access knowledge or other resources. With the combination of the R&D collaboration network and the Airbus production network on a spatial level, we find additional support for SBS, as those regions whose actors participate most frequently in both networks show the greatest share of successful actors. Nevertheless, especially with many SMEs in the industry, the European aerospace industry faces future risks from its ambidexterity, as coming challenges point towards a stronger emphasis on production skills.

The present study raises a number of questions for future research. Besides the success factors considered, there are of course several further possibilities which are worth investigating, especially in the context of the aerospace industry. Besides a differentiation between small and large actors, as well as companies and research organizations, the consideration of governmental and state influence—as well as noting differences between civil- and defense-related aspects that are decisive in the aerospace industry — will provide a more detailed picture of the industry's structural development. Further, an interesting prospect is to consider Airbus's competitor Boeing, repeating the analysis within its network. Directly related to our findings is the question of whether the core actors and regions have been established due to their spatial or thematic relevance. Especially in the light of ambidexterity, the question arises how to promote especially SMEs to be able to fulfill the needs of the market, taking over risk and revenue tasks and coping with the challenges posed to the European aerospace industry in the future. Flexible policies appear to be essential to the aerospace industry, due to its heterogeneous structure of several large hub companies and many SMEs, as well as its overlapping exploration and exploitation periods within the subsystems: policies fostering science-industry linkages as well as policies stimulating SME to enhance production skills are crucial for the competiveness of the aerospace industry.

Acknowledgments

This work has been funded as part of the INSPIRED project, financed by the German science foundation DFG, grant PY 70/8-1, and the Austrian science foundation FWF, grant I 886-G11.

References

Abernathy, W. J. and Utterback, J.M. (1978): Patterns of Industrial Innovation, in: Technology Review, Vol. 80, No. 7, p. 40-47.

Acha, V., Brusoni, S., Prencipe, A. (2007): Exploring the miracle: strategy and management of the knowledge base in the aeronautics industry, Int. J. Innov. Technol. Manag. 4, p. 15–39.

Alfonso-Gil, J. (Ed.) et al. (2007). European Aeronautics: The Southwestern Axis, Springer, New York, NY.

Almendral, J. A., Oliveira, J., Lopez, L., Mendes, J. and Sanjuan, M. A. (2007): The network of scientific collaborations within the European framework programme. Physica A: Statistical Mechanics and its Applications, 384(2):675-683.

Baldwin, C.Y. and Clark, K.B. (2000). *Design rules: The power of modularity*, Cambridge: MIT Press.

Barabási, A.L. and Albert, R. (1999). Emergence of scaling in random networks, *Science*, **286** (5439), pp. 509-512.

Beaudry, C.: Entry, growth and patenting in industrial clusters: a study of the aerospace industry in the UK, Econ. Bus. 8 (2001) 405–436.

Benton,W.C., Maloni, M., 2005. The influence of power driven buyer/seller relationships on supply chain satisfaction. Journal of OperationsManagement 23 (1), 1–22.

Biggiero, L. and Pier Paolo Angelini: Hunting scale-free properties in R&D collaboration networks: Self-organization, power-law and policy issues in the European aerospace research area, Technological Forecasting and Social Change, Available online 10 May 2014, ISSN 0040-1625, http://dx.doi.org/10.1016/j.techfore.2014.04.009.

Bonaccorsi, A. & Giuri, P. 2001. The long-term evolution of vertically-related industries. International Journal of Industrial Organization, 19: 1053–1083.

Braddorn,D. and K. Hartley, The competitiveness of the UK aerospace industry, Appl. Econ. 39 (2007) 715–726.

Brégier, F. (2011). Airbus company presentation on the Global Investor Forum 15th – 16th December 2011.

Breschi, S. and Cusmano, L. (2004). Unveiling the texture of a European Research Area: Emergence of oligarchic networks under EU Framework Programmes. International Journal of Technology Management, 27 (8), 747-72.

Broekel, T. and Boschma, R. A. (2010). Aviation, space or aerospace? exploring the knowledge networks of two industries in the Netherlands. Working Papers on Innovation and Space, 2010-05.

Buenstorf, G., Klepper, S. (2009) Heritage and agglomeration. The Akron tyre cluster revisited. The Economic Journal, 119: 705–733.

Burt, R.S. 1995, Structural holes: The social structure of competition, Harvard University Press.

CORDIS (1998): Fifth Framework Programme (1998-2002). Available from http://cordis.europa.eu/fp5/about.htm

Dosi, G. (1982). Technological Paradigms and Technological Trajectories: A Suggested Interpretation of the Determinants and Directions of Technical Change. Research Policy, 11(3), pp. 147–62.

Doz, Y. (1988): Technology partnership between larger and smaller firms: some critical issues. In: Contractor, F. and Lorange, P. (1988): Cooperative strategies in International Business, Lexington, Mass., Lexington Books.

Dussauge, P. and B. Garrette, Determinants of success in international strategic alliances: evidence from the global aerospace industry, J. Int. Bus. Stud. 26 (1995) 505–530.

Eriksson, S.: Technology spill-over from the aircraft industry: the case of Volvo Aero, Technovation 20 (2000) 653–664.

Esposito, E. and Raffa, L. (2006). Evolution of the supply chain in the aircraft industry. IPSERA Conference, San Diego.

European Council (1998): Council decision of 22 December 1998 concerning the rules for the participation of undertakings, research centres and universities and for the dissemination of research results for the implementation of the fifth framework programme of the European Community (1998-2002).

Freeman, L. C. (1977): A set of measures of centrality based on betweenness. Sociometry 40; p. 35-41.

Frenken, K. (2000): A complexity approach to innovation networks: the case of the aircraft industry (1909–1997), Res. Policy 29 (2000) 257–272.

Frenken, K. and Leydesdorff, L. (2000). Scaling trajectories in civil aircraft (1913-1970). Research Policy, 29(3), 331-348.

Giampaolo, T. (2006): The Gas Turbine Handbook, The Fairmont Press, 3rd edition, USA.

Gort, M., Klepper, S., 1982, Time paths in the diffusion of product innovations, Economic Journal, 92, 630-653.

Granovetter, M. S. (1973): The Strength of Weak Ties, in: American Journal of Sociology, Vol. 78, No. 6, Seiten 1360-1380

Green, S.D., Fernie, S., Weller, S. (2005) Making sense of supply chain management: a comparative study of aerospace and construction, Construction Management and Economics, 23(6), 579-593

Guffarth, D. and Barber, M.J. (2013): The European aerospace R&D collaboration network, FZID Discussion Paper, No. 84-2013, http://nbn-resolving.de/urn:nbn:de:bsz:100-opus-9038

Gupta AK, Smith KG, Shalley CE. 2006. The interplay between exploration and exploitation. *Academy of Management Journal* **49**(4): 693–706.

Hagedoorn, J. and Wang, N. (2012). Is there complementarity or substitutability between internal and external R&D strategies? Research Policy, 41(6), 1072-1083.

Hanneman, Robert A. / Riddle, Mark (2005): Introduction to social network methods. Riverside: University of California. URL: http://www.faculty.ucr.edu/~hanneman/nettext/[Stand: 22. Oktober 2006].

Hansen, M.T. (1999): The Search-Transfer Problem: The Role of Weak Ties in Sharing Knowledge across Organization Subunits. Administrative Science Quarterly, Vol. 44, No. 1. (Mar., 1999), pp. 82-111.

Henderson, R. M./Clark, K. B. (1990): Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms, in: Administrative Science Quarterly, Vol. 35, No. 1, Special Issue: Technology, Organizations and Innovation, Seiten 9-30

Hobday, M., 1998. Product complexity, innovation and industrial organisation. Research Policy 26, 689–710.

Ibarra, H. 1993, „Network centrality, power, and innovation involvement: Determinants of technical and administrative roles“, Academy of Management Journal, pp. 471-501.

Jackson, I.: The future of the defense firm: the case of the UK aerospace cluster, Def. Peace Econ. 15 (2004) 519–534.

Jordan, J. and J. Lowe, Protecting strategic knowledge: insights from collaborative agreements in the aerospace sector, Tech. Anal. Strat. Manag. 16 (2004) 241–259.

Klepper, S. (1996): Entry, exit, growth, and innovation over the product life cycle, in: The American economic review, Vol 86, No. 3, Seiten 562-583

Klepper, S. (1997): Industry life cycles, in: Industrial and corporate change, Vol. 6, No. 1, Seiten 145-182

Lefebvre, E. and L.A. Lefebvre, Global strategic benchmarking, critical capabilities and performance of aerospace subcontractors, Technovation 18 (1998) 223–234.

Levin, R. C, A. K. Klevorick, R. R. Nelson and S. G. Winter (1987). 'Appropriating the retums from industrial research and development', Brookings Papers on Economic Activity, pp. 783-820.

Levinthal, D. A. and J. G. March (1993). 'The myopia of learning', *Strategic Management Journal,* Winter Special Issue, 14, pp. 95-1 12.

Lublinsky, A.E. (2003): Does geographic proximity matter? Evidence from clustered and non-clustered aeronautic firms in Germany, Reg. Stud. 37 (2003) 453–468.

M.J. Barber, A. Krueger, T. Krueger, and T. Roediger-Schluga, Phys. Rev. E 73, 036132 (2006)

Malerba, F. (2004): Sectoral systems: How and why innovation differs across sectors. In J. Fagerberg, D. Mowery & R. Nelson (Eds.). Oxford Handbook of Innovation. Oxford University Press.

Mansfield, E., The economics of technological change, W.W. Norton & Company (1968).

March, J. G. (1991). 'Exploration and exploitation in organizational leaming'. *Organization Science, 2*,pp. 71-87.

Mayhew, B. H., & Levinger, R. 1976. Size and density of interaction in human aggregates. American Journal of Sociology, 82: 86-110.

Mentzer, J.T., W. DeWitt, J.S. Keebler, S. Min, N.W. Nix, C.D. Smith and Z.G. Zacharia. ‘‘Defining Supply Chain Management,’’ Journal of Business Logistics, (22:2), 2001, pp. 1-25.

Miotti, L. and Sachwald, F. (2003): Co-operative R&D: why and with whom?: An integrated framework of analysis Research Policy, 32, 8, 1481-1499.

Nelson, R. and Winter, S. (1977). In Search of a Useful Theory of Innovation. Research Policy 5.

Newman, M.E.J. (2003): Mixing patterns in networks. Phys. Rev. E 67, 026126.

Niosi, J. and M. Zhegu (2008). Innovation System Lifecycle in the Aircraft Sector. DRUID, Copenhagen, CBS, Denmark.

Niosi, J. and M. Zhegu, Aerospace clusters: local or global knowledge spillovers? Ind. Innov. 12 (2005) 5–29.

Niosi, J. and Zhegu, M. (2010). Anchor Tenants and Regional Innovation Systems: The Aircraft Industry. International Journal of Technology Management 50, pp. 263 284.

Philips, A.C. (1971): Technology and market structure, Lexington Books, Toronto.

Powell, W.W., K.W. Koput, L. Smith-Doerr, Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology, Adm. Sci. Q. 41 (1996) 116–145.

Pyka, A. (2011): Avoiding evolutionary inefficiencies in innovation networks. FZID discussion papers 35-2011.

Pyka, A. and Schön, B. (2012), ‘Towards a Taxonomy of Innovation Networks’, FZID Discussion Paper.

Pyka, A./Buchmann, T. (2012): Netzwerkindikatoren zur Bewertung der innovativen Leistungsfähigkeit, in: Controlling & Management, Sonderheft 1/2012, Wiesbaden, Gabler, Seiten 22-28

Roberts, E. and Berry, C. (1985): Entering new business: strategies for success. Sloan Management Review, Vol. 26, No. 3, published in Roberts, E. (1987): Generating Technological Innovation, Oxford, Oxford University Press.

Roediger-Schluga, T. and Barber, M.J. (2008). R&D collaboration networks in the European Framework Programmes: Data processing, network construction and selected results. International Journal of Foresight and Innovation Policy 4, 321–347.

Rothwell, R. (1990): Successful industrial innovation: critical factors for the 1990s, in: R&D Management Vol. 22, No. 3, Seiten 221-240

Rothwell, R. (2002): Towards the Fifth-Generation Innovation Process, in: Henry, J./ Mayle, D. (Hrsg.): Managing Innovation and Change, 2. Auflage, Sage Publications, London, Thousand Oaks, New Delhi, Seiten 115-135

Scott, John (1994): Social network analysis. A handbook, London u.a: Sage.

Teece, D. J. (1986): Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy, in: Research policy, Vol. 15, No. 6, Seiten 285-305

Tushman, M. L., & O’Reilly, C. A. 1996. Ambidextrous organizations: Managing evolutionary and revolutionary change. California Management Review,38(4): 8–30.

Utterback, J. (1994). Mastering the Dynamics of Innovation. Boston, Harvard Business School Press.

Wassermann, S. and Faust, K. (1994): Social Networks Analysis, Cambridge University Press, Cambridge.

Watts, D.J. and S.H. Strogatz, Collective dynamics of ‘small-world’ networks, Nature 393 (1998) 440–442.

Weber, H.J., Aaron J. Gellman, George W. Hamlin (2005): Study of European Government support to civil aeronautics R&D, NASA.

FZID Discussion Papers

Competence Centers:

IK:	Innovation and Knowledge
ICT:	Information Systems and Communication Systems
CRFM:	Corporate Finance and Risk Management
HCM:	Health Care Management
CM:	Communication Management
MM:	Marketing Management
ECO:	Economics

Nr.	Autor	Titel	CC
01-2009	Julian P. Christ	NEW ECONOMIC GEOGRAPHY RELOADED: Localized Knowledge Spillovers and the Geography of Innovation	IK
02-2009	André P. Slowak	MARKET FIELD STRUCTURE & DYNAMICS IN INDUSTRIAL AUTOMATION	IK
03-2009	Pier Paolo Saviotti and Andreas Pyka	GENERALIZED BARRIERS TO ENTRY AND ECONOMIC DEVELOPMENT	IK
04-2009	Uwe Focht, Andreas Richter, and Jörg Schiller	INTERMEDIATION AND MATCHING IN INSURANCE MARKETS	HCM
05-2009	Julian P. Christ and André P. Slowak	WHY BLU-RAY VS. HD-DVD IS NOT VHS VS. BETAMAX: THE CO-EVOLUTION OF STANDARD-SETTING CONSORTIA	IK
06-2009	Gabriel Felbermayr, Mario Larch, and Wolfgang Lechthaler	UNEMPLOYMENT IN AN INTERDEPENDENT WORLD	ECO
07-2009	Steffen Otterbach	MISMATCHES BETWEEN ACTUAL AND PREFERRED WORK TIME: Empirical Evidence of Hours Constraints in 21 Countries	HCM
08-2009	Sven Wydra	PRODUCTION AND EMPLOYMENT IMPACTS OF NEW TECHNOLOGIES – ANALYSIS FOR BIOTECHNOLOGY	IK
09-2009	Ralf Richter and Jochen Streb	CATCHING-UP AND FALLING BEHIND KNOWLEDGE SPILLOVER FROM AMERICAN TO GERMAN MACHINE TOOL MAKERS	IK

Nr.	Autor	Titel	CC
10-2010	Rahel Aichele and Gabriel Felbermayr	KYOTO AND THE CARBON CONTENT OF TRADE	ECO
11-2010	David E. Bloom and Alfonso Sousa-Poza	ECONOMIC CONSEQUENCES OF LOW FERTILITY IN EUROPE	HCM
12-2010	Michael Ahlheim and Oliver Frör	DRINKING AND PROTECTING – A MARKET APPROACH TO THE PRESERVATION OF CORK OAK LANDSCAPES	ECO
13-2010	Michael Ahlheim, Oliver Frör, Antonia Heinke, Nguyen Minh Duc, and Pham Van Dinh	LABOUR AS A UTILITY MEASURE IN CONTINGENT VALUATION STUDIES – HOW GOOD IS IT REALLY?	ECO
14-2010	Julian P. Christ	THE GEOGRAPHY AND CO-LOCATION OF EUROPEAN TECHNOLOGY-SPECIFIC CO-INVENTORSHIP NETWORKS	IK
15-2010	Harald Degner	WINDOWS OF TECHNOLOGICAL OPPORTUNITY DO TECHNOLOGICAL BOOMS INFLUENCE THE RELATIONSHIP BETWEEN FIRM SIZE AND INNOVATIVENESS?	IK
16-2010	Tobias A. Jopp	THE WELFARE STATE EVOLVES: GERMAN KNAPPSCHAFTEN, 1854-1923	HCM
17-2010	Stefan Kirn (Ed.)	PROCESS OF CHANGE IN ORGANISATIONS THROUGH eHEALTH	ICT
18-2010	Jörg Schiller	ÖKONOMISCHE ASPEKTE DER ENTLOHNUNG UND REGULIERUNG UNABHÄNGIGER VERSICHERUNGSVERMITTLER	HCM
19-2010	Frauke Lammers and Jörg Schiller	CONTRACT DESIGN AND INSURANCE FRAUD: AN EXPERIMENTAL INVESTIGATION	HCM
20-2010	Martyna Marczak and Thomas Beissinger	REAL WAGES AND THE BUSINESS CYCLE IN GERMANY	ECO
21-2010	Harald Degner and Jochen Streb	FOREIGN PATENTING IN GERMANY, 1877-1932	IK
22-2010	Heiko Stüber and Thomas Beissinger	DOES DOWNWARD NOMINAL WAGE RIGIDITY DAMPEN WAGE INCREASES?	ECO
23-2010	Mark Spoerer and Jochen Streb	GUNS AND BUTTER – BUT NO MARGARINE: THE IMPACT OF NAZI ECONOMIC POLICIES ON GERMAN FOOD CONSUMPTION, 1933-38	ECO

Nr.	Autor	Titel	CC
24-2011	Dhammika Dharmapala and Nadine Riedel	EARNINGS SHOCKS AND TAX-MOTIVATED INCOME-SHIFTING: EVIDENCE FROM EUROPEAN MULTINATIONALS	ECO
25-2011	Michael Schuele and Stefan Kirn	QUALITATIVES, RÄUMLICHES SCHLIEßEN ZUR KOLLISIONSERKENNUNG UND KOLLISIONSVERMEIDUNG AUTONOMER BDI-AGENTEN	ICT
26-2011	Marcus Müller, Guillaume Stern, Ansger Jacob and Stefan Kirn	VERHALTENSMODELLE FÜR SOFTWAREAGENTEN IM PUBLIC GOODS GAME	ICT
27-2011	Monnet Benoit Patrick Gbakoua and Alfonso Sousa-Poza	ENGEL CURVES, SPATIAL VARIATION IN PRICES AND DEMAND FOR COMMODITIES IN CÔTE D’IVOIRE	ECO
28-2011	Nadine Riedel and Hannah Schildberg-Hörisch	ASYMMETRIC OBLIGATIONS	ECO
29-2011	Nicole Waidlein	CAUSES OF PERSISTENT PRODUCTIVITY DIFFERENCES IN THE WEST GERMAN STATES IN THE PERIOD FROM 1950 TO 1990	IK
30-2011	Dominik Hartmann and Atilio Arata	MEASURING SOCIAL CAPITAL AND INNOVATION IN POOR AGRICULTURAL COMMUNITIES. THE CASE OF CHÁPARRA - PERU	IK
31-2011	Peter Spahn	DIE WÄHRUNGSKRISENUNION DIE EURO-VERSCHULDUNG DER NATIONALSTAATEN ALS SCHWACHSTELLE DER EWU	ECO
32-2011	Fabian Wahl	DIE ENTWICKLUNG DES LEBENSSTANDARDS IM DRITTEN REICH – EINE GLÜCKSÖKONOMISCHE PERSPEKTIVE	ECO
33-2011	Giorgio Triulzi, Ramon Scholz and Andreas Pyka	R&D AND KNOWLEDGE DYNAMICS IN UNIVERSITY-INDUSTRY RELATIONSHIPS IN BIOTECH AND PHARMACEUTICALS: AN AGENT-BASED MODEL	IK
34-2011	Claus D. Müller-Hengstenberg and Stefan Kirn	ANWENDUNG DES ÖFFENTLICHEN VERGABERECHTS AUF MODERNE IT SOFTWAREENTWICKLUNGSVERFAHREN	ICT
35-2011	Andreas Pyka	AVOIDING EVOLUTIONARY INEFFICIENCIES IN INNOVATION NETWORKS	IK
36-2011	David Bell, Steffen Otterbach and Alfonso Sousa-Poza	WORK HOURS CONSTRAINTS AND HEALTH	HCM
37-2011	Lukas Scheffknecht and Felix Geiger	A BEHAVIORAL MACROECONOMIC MODEL WITH ENDOGENOUS BOOM-BUST CYCLES AND LEVERAGE DYNAMICS	ECO
38-2011	Yin Krogmann and Ulrich Schwalbe	INTER-FIRM R&D NETWORKS IN THE GLOBAL PHARMACEUTICAL BIOTECHNOLOGY INDUSTRY DURING 1985–1998: A CONCEPTUAL AND EMPIRICAL ANALYSIS	IK

Nr.	Autor	Titel	CC
39-2011	Michael Ahlheim, Tobias Börger and Oliver Frör	RESPONDENT INCENTIVES IN CONTINGENT VALUATION: THE ROLE OF RECIPROCITY	ECO
40-2011	Tobias Börger	A DIRECT TEST OF SOCIALLY DESIRABLE RESPONDING IN CONTINGENT VALUATION INTERVIEWS	ECO
41-2011	Ralf Rukwid and Julian P. Christ	QUANTITATIVE CLUSTERIDENTIFIKATION AUF EBENE DER DEUTSCHEN STADT- UND LANDKREISE (1999-2008)	IK

Nr.	Autor	Titel	CC
42-2012	Benjamin Schön and Andreas Pyka	A TAXONOMY OF INNOVATION NETWORKS	IK
43-2012	Dirk Foremny and Nadine Riedel	BUSINESS TAXES AND THE ELECTORAL CYCLE	ECO
44-2012	Gisela Di Meglio, Andreas Pyka and Luis Rubalcaba	VARIETIES OF SERVICE ECONOMIES IN EUROPE	IK
45-2012	Ralf Rukwid and Julian P. Christ	INNOVATIONSPOTENTIALE IN BADEN-WÜRTTEMBERG: PRODUKTIONSCLUSTER IM BEREICH „METALL, ELEKTRO, IKT“ UND REGIONALE VERFÜGBARKEIT AKADEMISCHER FACHKRÄFTE IN DEN MINT-FÄCHERN	IK
46-2012	Julian P. Christ and Ralf Rukwid	INNOVATIONSPOTENTIALE IN BADEN-WÜRTTEMBERG: BRANCHENSPEZIFISCHE FORSCHUNGS- UND ENTWICKLUNGSAKTIVITÄT, REGIONALES PATENTAUFKOMMEN UND BESCHÄFTIGUNGSSTRUKTUR	IK
47-2012	Oliver Sauter	ASSESSING UNCERTAINTY IN EUROPE AND THE US - IS THERE A COMMON FACTOR?	ECO
48-2012	Dominik Hartmann	SEN MEETS SCHUMPETER. INTRODUCING STRUCTURAL AND DYNAMIC ELEMENTS INTO THE HUMAN CAPABILITY APPROACH	IK
49-2012	Harold Paredes-Frigolett and Andreas Pyka	DISTAL EMBEDDING AS A TECHNOLOGY INNOVATION NETWORK FORMATION STRATEGY	IK
50-2012	Martyna Marczak and Víctor Gómez	CYCLICALITY OF REAL WAGES IN THE USA AND GERMANY: NEW INSIGHTS FROM WAVELET ANALYSIS	ECO
51-2012	André P. Slowak	DIE DURCHSETZUNG VON SCHNITTSTELLEN IN DER STANDARDSETZUNG: FALLBEISPIEL LADESYSTEM ELEKTROMOBILITÄT	IK
52-2012	Fabian Wahl	WHY IT MATTERS WHAT PEOPLE THINK - BELIEFS, LEGAL ORIGINS AND THE DEEP ROOTS OF TRUST	ECO
53-2012	Dominik Hartmann und Micha Kaiser	STATISTISCHER ÜBERBLICK DER TÜRKISCHEN MIGRATION IN BADEN-WÜRTTEMBERG UND DEUTSCHLAND	IK
54-2012	Dominik Hartmann, Andreas Pyka, Seda Aydin, Lena Klauß, Fabian Stahl, Ali Santircioglu, Silvia Oberegelsbacher, Sheida Rashidi, Gaye Onan und Suna Erginkoç	IDENTIFIZIERUNG UND ANALYSE DEUTSCH-TÜRKISCHER INNOVATIONSNETZWERKE. ERSTE ERGEBNISSE DES TGIN-PROJEKTES	IK
55-2012	Michael Ahlheim, Tobias Börger and Oliver Frör	THE ECOLOGICAL PRICE OF GETTING RICH IN A GREEN DESERT: A CONTINGENT VALUATION STUDY IN RURAL SOUTHWEST CHINA	ECO

Nr.	Autor	Titel	CC
56-2012	Matthias Strifler Thomas Beissinger	FAIRNESS CONSIDERATIONS IN LABOR UNION WAGE SETTING – A THEORETICAL ANALYSIS	ECO
57-2012	Peter Spahn	INTEGRATION DURCH WÄHRUNGSUNION? DER FALL DER EURO-ZONE	ECO
58-2012	Sibylle H. Lehmann	TAKING FIRMS TO THE STOCK MARKET: IPOS AND THE IMPORTANCE OF LARGE BANKS IN IMPERIAL GERMANY 1896-1913	ECO
59-2012	Sibylle H. Lehmann, Philipp Hauber, Alexander Opitz	POLITICAL RIGHTS, TAXATION, AND FIRM VALUATION – EVIDENCE FROM SAXONY AROUND 1900	ECO
60-2012	Martyna Marczak and Víctor Gómez	SPECTRAN, A SET OF MATLAB PROGRAMS FOR SPECTRAL ANALYSIS	ECO
61-2012	Theresa Lohse and Nadine Riedel	THE IMPACT OF TRANSFER PRICING REGULATIONS ON PROFIT SHIFTING WITHIN EUROPEAN MULTINATIONALS	ECO

Nr.	Autor	Titel	CC
62-2013	Heiko Stüber	REAL WAGE CYCLICALITY OF NEWLY HIRED WORKERS	ECO
63-2013	David E. Bloom and Alfonso Sousa-Poza	AGEING AND PRODUCTIVITY	HCM
64-2013	Martyna Marczak and Víctor Gómez	MONTHLY US BUSINESS CYCLE INDICATORS: A NEW MULTIVARIATE APPROACH BASED ON A BAND-PASS FILTER	ECO
65-2013	Dominik Hartmann and Andreas Pyka	INNOVATION, ECONOMIC DIVERSIFICATION AND HUMAN DEVELOPMENT	IK
66-2013	Christof Ernst, Katharina Richter and Nadine Riedel	CORPORATE TAXATION AND THE QUALITY OF RESEARCH AND DEVELOPMENT	ECO
67-2013	Michael Ahlheim, Oliver Frör, Jiang Tong, Luo Jing and Sonna Pelz	NONUSE VALUES OF CLIMATE POLICY - AN EMPIRICAL STUDY IN XINJIANG AND BEIJING	ECO
68-2013	Michael Ahlheim and Friedrich Schneider	CONSIDERING HOUSEHOLD SIZE IN CONTINGENT VALUATION STUDIES	ECO
69-2013	Fabio Bertoni and Tereza Tykvová	WHICH FORM OF VENTURE CAPITAL IS MOST SUPPORTIVE OF INNOVATION? EVIDENCE FROM EUROPEAN BIOTECHNOLOGY COMPANIES	CFRM
70-2013	Tobias Buchmann and Andreas Pyka	THE EVOLUTION OF INNOVATION NETWORKS: THE CASE OF A GERMAN AUTOMOTIVE NETWORK	IK
71-2013	B. Vermeulen, A. Pyka, J. A. La Poutré, A. G. de Kok	CAPABILITY-BASED GOVERNANCE PATTERNS OVER THE PRODUCT LIFE-CYCLE	IK
72-2013	Beatriz Fabiola López Ulloa, Valerie Møller, Alfonso Sousa-Poza	HOW DOES SUBJECTIVE WELL-BEING EVOLVE WITH AGE? A LITERATURE REVIEW	HCM
73-2013	Wencke Gwozdz, Alfonso Sousa-Poza, Lucia A. Reisch, Wolfgang Ahrens, Stefaan De Henauw, Gabriele Eiben, Juan M. Fernández-Alvira, Charalampos Hadjigeorgiou, Eva Kovács, Fabio Lauria, Toomas Veidebaum, Garrath Williams, Karin Bammann	MATERNAL EMPLOYMENT AND CHILDHOOD OBESITY – A EUROPEAN PERSPECTIVE	HCM
74-2013	Andreas Haas, Annette Hofmann	RISIKEN AUS CLOUD-COMPUTING-SERVICES: FRAGEN DES RISIKOMANAGEMENTS UND ASPEKTE DER VERSICHERBARKEIT	HCM

75-2013	Yin Krogmann, Nadine Riedel and Ulrich Schwalbe	INTER-FIRM R&D NETWORKS IN PHARMACEUTICAL BIOTECHNOLOGY: WHAT DETERMINES FIRM'S CENTRALITY-BASED PARTNERING CAPABILITY?	ECO, IK
76-2013	Peter Spahn	MACROECONOMIC STABILISATION AND BANK LENDING: A SIMPLE WORKHORSE MODEL	ECO
77-2013	Sheida Rashidi, Andreas Pyka	MIGRATION AND INNOVATION – A SURVEY	IK
78-2013	Benjamin Schön, Andreas Pyka	THE SUCCESS FACTORS OF TECHNOLOGY-SOURCING THROUGH MERGERS & ACQUISITIONS – AN INTUITIVE META-ANALYSIS	IK
79-2013	Irene Prostolupow, Andreas Pyka and Barbara Heller-Schuh	TURKISH-GERMAN INNOVATION NETWORKS IN THE EUROPEAN RESEARCH LANDSCAPE	IK
80-2013	Eva Schlenker, Kai D. Schmid	CAPITAL INCOME SHARES AND INCOME INEQUALITY IN THE EUROPEAN UNION	ECO
81-2013	Michael Ahlheim, Tobias Börger and Oliver Frör	THE INFLUENCE OF ETHNICITY AND CULTURE ON THE VALUATION OF ENVIRONMENTAL IMPROVEMENTS – RESULTS FROM A CVM STUDY IN SOUTHWEST CHINA –	ECO
82-2013	Fabian Wahl	DOES MEDIEVAL TRADE STILL MATTER? HISTORICAL TRADE CENTERS, AGGLOMERATION AND CONTEMPORARY ECONOMIC DEVELOPMENT	ECO
83-2013	Peter Spahn	SUBPRIME AND EURO CRISIS: SHOULD WE BLAME THE ECONOMISTS?	ECO
84-2013	Daniel Guffarth, Michael J. Barber	THE EUROPEAN AEROSPACE R&D COLLABORATION NETWORK	IK
85-2013	Athanasios Saitis	KARTELLBEKÄMPFUNG UND INTERNE KARTELLSTRUKTUREN: EIN NETZWERKTHEORETISCHER ANSATZ	IK

Nr.	Autor	Titel	CC
86-2014	Stefan Kirn, Claus D. Müller-Hengstenberg	INTELLIGENTE (SOFTWARE-)AGENTEN: EINE NEUE HERAUSFORDERUNG FÜR DIE GESELLSCHAFT UND UNSER RECHTSSYSTEM?	ICT
87-2014	Peng Nie, Alfonso Sousa-Poza	MATERNAL EMPLOYMENT AND CHILDHOOD OBESITY IN CHINA: EVIDENCE FROM THE CHINA HEALTH AND NUTRITION SURVEY	HCM
88-2014	Steffen Otterbach, Alfonso Sousa-Poza	JOB INSECURITY, EMPLOYABILITY, AND HEALTH: AN ANALYSIS FOR GERMANY ACROSS GENERATIONS	HCM
89-2014	Carsten Burhop, Sibylle H. Lehmann-Hasemeyer	THE GEOGRAPHY OF STOCK EXCHANGES IN IMPERIAL GERMANY	ECO
90-2014	Martyna Marczak, Tommaso Proietti	OUTLIER DETECTION IN STRUCTURAL TIME SERIES MODELS: THE INDICATOR SATURATION APPROACH	ECO
91-2014	Sophie Urmetzer, Andreas Pyka	VARIETIES OF KNOWLEDGE-BASED BIOECONOMIES	IK
92-2014	Bogang Jun, Joongho Lee	THE TRADEOFF BETWEEN FERTILITY AND EDUCATION: EVIDENCE FROM THE KOREAN DEVELOPMENT PATH	IK
93-2014	Bogang Jun, Tai-Yoo Kim	NON-FINANCIAL HURDLES FOR HUMAN CAPITAL ACCUMULATION: LANDOWNERSHIP IN KOREA UNDER JAPANESE RULE	IK
94-2014	Michael Ahlheim, Oliver Frör, Gerhard Langenberger and Sonna Pelz	CHINESE URBANITES AND THE PRESERVATION OF RARE SPECIES IN REMOTE PARTS OF THE COUNTRY – THE EXAMPLE OF EAGLEWOOD	ECO
95-2014	Harold Paredes-Frigolett, Andreas Pyka, Javier Pereira and Luiz Flávio Autran Monteiro Gomes	RANKING THE PERFORMANCE OF NATIONAL INNOVATION SYSTEMS IN THE IBERIAN PENINSULA AND LATIN AMERICA FROM A NEO-SCHUMPETERIAN ECONOMICS PERSPECTIVE	IK
96-2014	Daniel Guffarth, Michael J. Barber	NETWORK EVOLUTION, SUCCESS, AND REGIONAL DEVELOPMENT IN THE EUROPEAN AEROSPACE INDUSTRY	IK