Interregional and international knowledge flows in medium technology sectors: The role of formal and informal institutions

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Abstract
Many scientific papers deal with the relevance of geographical proximity for the generation, acquisition and exploitation of new knowledge. SME in medium technology sectors serve as typical examples for firms, which are dependent on geographical proximity to sales markets and knowledge, as they have only limited resources for international knowledge strategies and need only incremental improvements integrated within tacit routine-based knowledge due to the maturity of their technologies. Increasing internationalisation of production systems, however, challenges geographically concentrated firms, and many policy initiatives and regional agencies have been introduced to help SME to extend their scope of knowledge flows. The paper will present a theoretical model on institutional prerequisites for SME to overcome the need for geographical proximity in the context of innovation and learning. The model is based on innovation system and knowledge management approaches but extend these approaches to evolutionary institutional processes including the role of cognitive patterns and trust. First empirical results of investigating a cluster in the German machinery sector will be used to proof the suitability of the theoretical model and to discuss policy implications for the region investigated.

Keywords: international knowledge flows, SME, aerospace clusters, metropolitan regions

JEL: R5; O3; L6

1. Introduction

The improvement of knowledge generation, diffusion and commercialisation is one of the major objectives of current EU policies. The creation of a European Research Area, the formulation of the objective to have 3% of the GDP invested into R&D (2/3 by private firms), and the increasing funds within the 7th EU framework on R&D are only the most visible symbols of this focus. In all EU member countries, governments developed national and regional innovation strategies to overcome strategic disadvantages within the global competition. Most of these activities are concentrated in high technology segments like ICT technologies, bio- and nano-technologies or space technologies, and it is expected that the creation of new knowledge at this technological edge will help to raise the productivity in other segments by disseminating key technologies (Janson et al., 2005). Most of the current European industrial employment, however, can be found in the small and medium-sized enterprises (SME) in medium technology sectors like machinery, basic chemicals or vehicle production. If they shall participate in this process of disseminating new leading-edge knowledge, it will be necessary for them to have access to global "knowledge pipelines" (Bathelt et al., 2002). But SME face specific challenges to be integrated into knowledge flows that are generated, improved, and used internationally and along the interfaces of science, industry and government (the well-known "triple-helix" structure, see Etzkowitz; Leydesdorff, 2000). The following paper will deal with these specific challenges and needs for additional institutional arrangements to improve the access of SME to knowledge flows.

The paper is divided into four parts. Firstly, a general theoretical framework is presented to describe the main challenges for SME in medium technology sectors to get access to international knowledge flows. This leads in a second part to some general requirements for formal or informal institutional arrangements to overcome these problems. We will present some approaches and criteria to assess existing institutions. In the third part, a brief case study will be presented to show some practical implications of the argumentation. The case study is based on the aircraft production sector in the German metropolitan region of Hamburg with aircraft production as a sector, where SME using medium technologies are confronted with new technological and organisational requirements and increasing international competition within the value chain. Simultaneously, the regional governments and private associations are interested to help SME to overcome these difficulties, as this would be a decisive prerequisite to prevent loss of industrial employment and knowledge to other countries. Thus, institutional arrangements would be used as an instrument to raise the attractiveness of the region as location for industrial SME. Finally, some conclusions are drawn on the basis of the theoretical insights and interim empirical results.

2. Theoretical discussion on international knowledge flows and medium technology SME

2.1 Terminology

At the beginning of the theoretical part, we try to outline and separate the basic terms and methodologies we are referring to. We are doing this, as most of the literature on knowledge management confuses the meaning of knowledge, information and data. To avoid however the necessity to translate expressions from knowledge management literature to our argumentation, we will follow in the later sections the terminology found in literature.

The paper follows an evolutionary institutional economics approach on knowledge management. Knowledge means an individual set of capabilities of acquiring, processing, interpreting and assessing data from own or foreign experiences as options to use them intended or subconsciously within rationales, imaginations or actions (Machlup, 1980; Stillings, 1995). Thus, knowledge can only be generated and adjusted on the individual level and knowledge is used in this paper only from a functional perspective, in particular in a context of academic or sci-

entific knowledge (episteme in Aristotelian terms) and technological knowledge (techne). Data are just expressions of recognitions. Information is data with a specific intended meaning. If information is shared, it depends on the individual knowledge base whether all parties have the same interpretation of the data and hence the same information (Denzau; North, 1994 on shared mental models). The management of knowledge means in this context processes to generate, examine and commercialise (exploit) the knowledge base (Benzler, Wink, 2005; Cooke, 2004, on the knowledge value chain). As the knowledge base is specific for every individual and generation, examination and exploitation this knowledge base require interaction with others' knowledge, problems occur due to different cognitive frames and free rider motivations (Wilkesmann, Rascher, 2004). Interaction as sharing of data can lead to a common knowledge based on common frames and understandings, which is part of the individual knowledge bases. Different cognitive frames refer to differences in the recognition and interpretation of data between individuals due to different languages, cultures, or contexts. As a consequence, it can be expected that a high diversity of knowledge bases will bear the highest expected impact of data sharing on the individual knowledge bases – as new cognitive frames and applications can be learnt beside the content – but also cause the highest costs due to high risks of misunderstandings and needs to translate into other contexts, which becomes harder the less codified the data are (Nooteboom, 1999). Free rider motivations are caused by the network characteristics of common cognitive frames (communication codes). The more individuals understand and use the cognitive frames, the more data can be exchanged and integrated into a common knowledge base (Cappellin, Steiner, 2004; Wink, 2003). But every individual will only participate, if he or she trusts in the credible announcements of the others to contribute to the common knowledge base. This trust has to be secured by common norms, which can be derived from common social or cultural backgrounds, professional or scientific communities, individual experiences and routines, or contracts.

As a consequence, institutions are needed to bridge the cognitive gap between the individual knowledge bases and to overcome the free rider motivations. Institutions are arrangements to reduce the uncertainty on others' actions (Ostrom, 1986). They can be informal or formal, related to or independent from organisations. Institutional economics aim at explanations for the emergence of specific institutions and their impact on economic processes. Evolutionary institutional economics consider the need to adjust the institutional framework (Hodgson, 1999; Wink, 2002). They include learning processes by the individuals using institutions explicitly or implicitly as well as adjustments to exogenous changes like new technologies, the emergence of new actors or influences from other institutions. With this in mind, we will stick to knowledge flows – a term, which is used here due to its popularity in scientific papers on knowledge management – as the exchange of data with similar cognitive frames, and to the generation, examination and exploitation of knowledge within an organisation (within a form) as changes to a common knowledge base enabled by similar cognitive frames, which is part of the individual knowledge bases of the individual employees.

2.2 From linear to hybrid models of innovation and technology transfer

The discussion on new challenges caused by international knowledge flows has to be integrated in a broader view on changes of innovation paradigms. Innovation has to be seen as the part of new knowledge produced by individuals (in a firm), which can be successfully commercialised due to a common understanding of the use of this knowledge by suppliers and demanders (Metcalfe, 2001, on the relevance of demanders for innovations).

Traditionally, within the technology driven sectors like medium technologies within machinery or vehicle production, basic research, R&D and product and process development were more or less separated. Basic and general applied research was done in public research institutes, and firms focussed on specific improvements of these general basic technologies (Dasgupta; David, 1994). Knowledge generation within the firm was concentrated on highly tacit

knowledge specified to intra-firm production processes and products. Thus, technology ("knowledge") diffusion within this model included the dissemination of general state-of-the-art qualifications within university courses for engineers and specific joint research cooperation contracts with technology-oriented university departments (universities of applied sciences, poly-technical universities). The main elements of the firm-specific knowledge base, however, were developed in-house, by internal R&D departments and/or specified tacit knowledge within in-house routines (Benzler; Wink, 2005). Particularly Germany has been quite successful in building an innovation system suitable for this process of knowledge generation and dissemination. The best-known elements of this system are the public research infrastructure for applied research by the Fraunhofer Society, additional private applied research infrastructure by the Steinbeis Foundation, public schemes for joint industrial research by SME and universities of applied sciences (Working Group Industrial Research AIF; industrial research association "Otto von Guericke") and technological working groups within business and professional associations like VDMA for machinery sector and VDI for engineers (Cooke, 2004; Janson et al., 2005). As a result, many German SME located in more or less peripheral regions succeeded in dominating small technological niche markets ("silent giants").
Within the last decade, many scientific papers dealt with changes of knowledge generation and dissemination processes. Two main driving forces of these changes have been identified:

- *increasing international (hyper-)competition*

Within the traditional segments, firms had the possibility to build up specific competencies for a longer time and developed international strategies subsequently with small sales representations at the beginning and increasing international production capacities with time. With international competition, multinational firms look for global sourcing and force their suppliers to compete directly with foreign firms and follow them to other countries (Cantwell; Piscitello, 2004). Furthermore, they expect to concentrate their business contacts to fewer system suppliers with more responsibilities according to international standards. As a result, suppliers are forced to increase the scale and scope of products and technologies available and to adjust their new knowledge to internationally standardised processes of knowledge examination.
What does this mean for knowledge management? From a cognitive perspective, firms are firstly forced to broaden their capacities to understand and use knowledge from different technologies. If they want to become system suppliers, they have to integrate knowledge from other segments of the final product and they have to look how to overcome boundaries between system elements. This means not only the need for more qualifications available within the firm but the integration of these qualifications into process routines within the firm (Argyris; Schön, 1996). Secondly, they have to learn to adjust to internationally standardised knowledge examination, which means an examination of the products or other forms of data expressing the knowledge by the supplying firm. For many engineering processes, national specificities restricted the understanding of common norms. International knowledge examination not only requires the understanding of the common norms, but also the capability to adjust the specific intra-firm processes optimally to these norms. In many cases, these standards are not provided by the original equipment manufacturers at the end of the value chain or the state as an external intermediary, but by specialised private engineering firms having the expertise (knowledge base) to assess data expressed at the boundaries between different scientific disciplines and technological fields.
From an organisational perspective, the broadening of the knowledge base to other technologies requires an assessment of institutional alternatives to complete integration. The emergence of network cooperation or joint working groups for specific products (Brown, Duguid, 1991; Brusoni, Prencipe, 2001) would be hybrid options to maintain the organisational struc-

ture of a SME by simultaneously increase the scale and scope of products. But whatever organisational solution would be chosen, the additional cognitive challenges require organisational adjustments to create incentives to the employees to disclose, share and use knowledge from different technological roots and to integrate processes and infrastructures for sharing knowledge into production routines.

- *changes within scientific knowledge production*

In the context of scientific (academic) research, changes towards a "mode 2" of knowledge production have been discussed for more than a decade (Gibbons et al. 1994; Novotny et al., 2001). The typical characteristics of these changes refer inter alia to the vanishing boundaries between incumbent scientific disciplines, the vanishing boundaries between abstract basic research and applications, the higher awareness by industry and also the affected public (environmental groups or ethical NGOs) on the impact by new scientific ideas and the increasing relevance of scientific debates in public media. As a consequence, scientific entrepreneurs act already as commercial suppliers of their own ideas and are directly involved into product development, as scientific progress needs the feedback from experiences within implementation. Again, firms face new challenges for the generation and exploitation of new knowledge. They need more cooperation to include knowledge from other disciplines and technological fields and they need to interact with scientific entrepreneurs who are at the boundary between academic science and product development. The tacit elements of new products, which have been developed in the linear model exclusively within the firm, are now dependent on specific cooperation with a diversity of R&D services suppliers. Many of the single scientific ideas are codified and easy to imitate, but the specificity can only be reached via the connectivity between the single ideas (Valentin; Jensen, 2002; Foss, 1999).
Table 1 summarises some of the major differences between the traditional and the newer models of innovation and knowledge management.

Table 1: Differences between traditional and science-based models of knowledge management

Characteristics	**Traditional model**	**Science based model**
Scientific base	Slow changes of technological paradigms	Overlapping of different disciplinary key paradigms
Knowledge base	Tacit and highly specialised	Codified with tacit elements
Organisational dimension	Vertical value chain with clear boundaries	Hierarchical value chains with hybrid organisations
Spatial dimension	Regional and ethno-centric	Trans-regional and hierarchical

2.3 Barriers to knowledge flows for SME in medium-technology sectors

SME are defined by size or organisational structures. In general, the number of employees or turnover is used as criteria to identify SME by size. For our purposes, organisational issues might be even more important. These issues include the restricted access to capital markets, as the companies do not sell shares in the stock exchange market, the dependence on single entrepreneurs (entrepreneurial families or teams), and fewer management hierarchies. Looking at the challenges described in the previous section, lacks of resources have been claimed for SME (Cappellin, Steiner, 2004; Wallsten, 2000):

- lack of capital to expand to other technology fields and raise to a system supplier
- lack of openness to formal cooperation structures with other SME due to fears of losing independence
- lack of experiences in internationalisation of production and knowledge sourcing
- lack of capacities to adjust to formal international standards

- lack of personal resources for the adjustment of R&D capacities to new modes of scientific knowledge production
- lack of experiences with sharing of tacit knowledge
- lack of capital to cover risks of newer and less proved technologies

The list can be added with more items without changing the basic message that SME will face greater challenges in their knowledge management. For SME in medium technology sectors additional problems occur due to the maturity of many of their technologies in use. This maturity means that a wide set of routines and tacit knowledge is already available and has to be integrated into any further incremental change. Thus, for any external cooperation partner sunk investments have to be made to understand these firm-specific knowledge elements and to adjust new ideas on technologies or materials. Even if new technologies are added to the incumbent medium technologies, these sunk investments are necessary to be compatible to the absorptive capacity of the firms (Benzler; Wink, 2005). Within the traditional model of innovation, many firms got routines to adjust their processes and products within the value chain or by close relationships to R&D cooperation partners (Miotti; Sachwald, 2003; Mora-Valentin et al., 2004). With the increasing scope of different technologies to be involved and direct impact by basic sciences these incumbent routines have to be adjusted.

Most of the literature on knowledge management is focussed on multinational companies, their involvement into global knowledge flows and their relationship to centres of scientific excellence (Cantwell; Iammarino, 2003; Amin; Cohendet, 2003). For SME, literature is restricted to the investigation of regional clusters or even regional innovation systems, which offer the opportunity to SME to participate by stressing the relational capital of trust and a high similarity of cognitive patterns (Malmberg; Maskell, 2002; Paci; Usai, 2000). But how can these regional approaches be connected to trans-national or trans-regional processes? The next section will discuss some institutional prerequisites.

3. Institutions as gatekeepers for SME to trans-national knowledge flows?

Institutional arrangements serve to reduce uncertainties on the behaviour of others. Such arrangements in the context analysed within this paper can be formal contracts of cooperation, formal or informal networks, joint associations, or informal commitments. In the context of knowledge management, these institutions affect two dimensions:

- *the cognitive dimension*

This dimension refers to the diversity of scientific and academic knowledge as well as the diversity of cognitive patterns (mental models) to interpret and apply this knowledge. Institutional arrangements might help SME to get access to knowledge from other firms and research organisations with a different knowledge base. The prerequisites for successful institutional arrangements affect two elements of the cognitive dimension, which might cause trade-offs: (1) the more individuals and organisations coming from different types of organisations and using different technologies and methodologies commit themselves to share knowledge, the greater could be the impact on learning for each participant, as they get the opportunity of being informed about something distant from their own knowledge base (Fujita, Thisse, 2002); (2) the more individuals and organisations coming from different types of organisations and using different technologies and methodologies commit themselves to share knowledge, the harder it will be for the individual participant to improve her (his) knowledge base, as the codes of communication are too different to understand messages from others (Nooteboom, 1999). Consequentially, criteria to describe and assess the impact of institutional arrangements in this context will cover three aspects:

  - differences of technological knowledge included
  - differences of organisations included
  - activities to reduce differences of cognitive patterns

- *the motivational dimension*

From an economic perspective, any decision to comply with institutional arrangements is based on comparisons between costs and benefits. The benefits of the institutional arrangements described here are the provision of common communication codes – data that can be interpreted in a way all participants understand – as a network good (Economides, 1996). Thus, the attractiveness of these arrangements depends on the deliveries by the institutional arrangement, e.g. access to specific data or activities to build up joint communication codes, and their exclusiveness. The costs refer to the obligation to comply with the arrangements, which means that the participants have to contribute to the common knowledge base. If it is possible for individuals or single organisations to get access to the knowledge shared with the help of the institutional arrangement without contributing themselves, the motivation to bear these costs will be minimised. Consequentially, the effectiveness of the institutional arrangements requires means to secure the exclusiveness of the common network good and means to enforce commitment by the participants of this arrangement (Nooteboom, 2002; Zaheer et al., 1998). The following table summarises these general and abstract prerequisites for institutional arrangements.

Table 2: Characteristics of effective institutional arrangements for inter-organisational knowledge management

Characteristics	**Objective**
Scope of technological knowledge included	Securing the diversity of knowledge and increasing the probability of novelties
Scope of organisations included	Securing the diversity of knowledge and the value added to bilateral cooperation
Similarity of challenges (belonging to the same value chain)	Increasing the probability of mutual benefits of cooperation
Deliveries	Securing the benefits for participation
Impact on cognitive frames	Preventing misunderstandings and disproportions between participants
Commitment and monitoring	Preventing free rider behaviour and increasing trust between participants
Exclusiveness and barriers to access	Securing the sustainability of benefits for participants

In the following section, we will apply these general argumentations to a case study of institutional arrangements to help SME in the aircraft industry in Hamburg to be integrated into trans-national knowledge flows. Institutional arrangements take up the advantages of geographical proximity within a region and connect this to the challenges of trans-national knowledge flows.

4. A case study: SME in the aircraft industry of Hamburg

4.1 Aircraft industry in Hamburg

The metropolitan region of Hamburg

Hamburg has a long lasting history as central location for international and interregional trade. It developed in the middle of the 11th century as a centre of spiritual and secular power. The first commercial relations – with the North to Iceland, Greenland and Finland – were taken in the time of the arising municipal community. Under the rule of the Schauenburg counts in the 12th century Hamburg experienced a considerable economic revival. The town find out duty-free trade and navigation during the time of the emperor Friedrich Barbarossa.

At that time its population counted about 1000-1500 inhabitants. Joining the trade town federation Hanseatic League in the 14th century, the city of Hamburg achieved a peak level in its development: as a north seaport for north to south and east to west (as well as vice versa) direction for the traffic it became the most important trade centre and gain influence.
Favoured by its geographical situation, the Hanseatic city of Hamburg develops as a significant port both for North and for Baltic Sea. At a point of intersection of important trans-European traffic routes, Hamburg connects the Scandinavian countries with the West and Southern Europe and makes the Central and East-European space achievable. New prospects opened up for Hamburg with the political happenings at the beginning of the 1990s: its East and Central German upstate, which has remained on the other side of the iron curtain in the post-war period, disclosed themselves back to Hamburg.
Since the beginning 1990s Hamburg's direct investments from abroad record a slightly increasing and (till the late 1990s) very sustainable course, that reached after a steep rise in the year 2002 an absolute height of 48,684.00 bn € (preliminary data by the Chamber of Commerce Hamburg, 2004). One can recognize in this intensification of the capital mobility the cheering up of the world economy caused after the turn.
The region of Hamburg won within the following years increasingly to meaning and charisma, which led to a population immigration as well as employment and economic growth. Whilst into the late 80s approx. 3.7 million inhabitants lived in the wide area of Hamburg[1], in 2002 their number counted already more than 4.1 million, including alone in the city of Hamburg over 288,000 people from different nationalities. In 2002 approx. 1.378 million people are employed in the metropolis. This yields, put into relation to the employable population, a value of 88.9% (with 90.0% for the city of Hamburg and 86.6% for the hinterland), what is above the nationwide average of 73.4%. Between 1997 and 2002 the occupation in Hamburg has increased by 5.0%, rating on the number of employees. Compared with the population growth for the same time this is a difference of 3.6 percentage points. Just on the contrary, the surrounding area shows a bigger population as an occupation growth. These discrepancies are to be led back to the integration of the Hamburg labour market with this of the surrounding areas. In 2001, 8.3% of the total population of the Hamburg surrounding countryside commute to the city of Hamburg. In comparison with the commuters to Hamburg those in the reversed direction could hardly put on value. And although at that time an almost constant positive commuter balance can be recognized, the increasing interweaving between Hamburg and its hinterland is unmistakable. In the period of 1997 to 2001 the number of the commuters from the surrounding areas to Hamburg has grown from 190,939 to 197,911; the number of the commuters on the reverse direction - from 42,104 to 47,359. This caused an increase in the commuter balance and it changed from 148,835 to 150,552.
The authors of a study of the future developments in the region of South Elbe (Untiedt et al. 2004) analyse the qualification structure of the employees at the place of residence and the same at the place of work and close down about the qualification structure of the commuters. It can be recognized that the group of the commuter to Hamburg consists of mainly high-educated people living in the surrounding countryside and working in the city.
While the previous explanations summarize the quantitative development of labour as a production factor, the level of employment is illustrated by the rate of unemployment. In the time period of 1987 – 2001 it has generally a diminishing trend. The share of the unemployed in the population part on an age able to work dropped down from 12.5% onto 8.7% and began

[1] The term ‚wide area of Hamburg' or the 'metropolis of Hamburg' summarizes in this paper both the city of Hamburg and its hinterland. As a 'hinterland' or 'surrounding area' we mean the following administrative districts of Schleswig-Holstein and Lower Saxony: Dithmarschen, Duchy of Lauenburg, Pinneberg, Segeberg, Steinburg, Stormarn as well as Cuxhaven, Harburg, Luechtow-Dannenberg, Lueneburg, Rotenburg-Wuemme, Soltau-Fallingbostel, Stade and Uelzen. All statistical data base on the annual statements of the Chamber of Commerce of Hamburg (Handelskammer Hamburg 2004).

increasing again since 2002. This trend applies to the city of Hamburg as well as to its surrounding areas. Even though the Hamburg unemployment rates extend slightly the region's average, they remain consistent under the federal average.
In comparison with Hamburg the gross value added in the surrounding countryside is low. 2001 it was 45.271 bn € and was by 33% below the Hamburg reference value. For 1992 till 2001 the value added in the surrounding countryside has grown by 23.3%, just 3.1 growths percent points below the Hamburg reference value of 26.4%. The largest part of the income in the region is gained in the service sector: 81.1% in Hamburg in the year 2001 and 77.3% in the metropolis Hamburg in the same year. This gives information about the increasing tertiarisation of the economy and therefore on an increase of the integration of the market of goods.
These developments on macro economical level also cause corresponding customisations in the politics and infrastructure of the metropolis. Hamburg attracts young people from home and abroad with more than 750 private educational institutions. The planned comprehensive university reform aims to raise the quality in teaching and research. The strengthening of the relations between universities and private economy boosts the innovation driving knowledge and transfer of technology. Other indicators of location's attractiveness, as a place to live in and to work at, are the numerous family-beneficial-programs like whole-day schools, sufficient provision of childcare facilities (for instance the "KITA voucher" system) and "family-friendly employee policy". Not at last, the opportunity of various culture and leisure activities seems attractive for people all ages. The green landscape (parks, rivers and woods) spreads out onto nearly the half of the Hamburg municipal area and makes it exciting for relaxation, excursion or sports. A musical, a cabaret, a ballet, an opera, more than 30 state and private theatres, about 200 art galleries and 40 Museums supply some of the highlights of the culture program, well-known in Germany and in the region. Therefore Hamburg is honoured by a lot of tourists as main culture destination.

The aerospace industry

An industrial engine of Hamburg is the aerospace industry. It is represented by the areas of aircraft construction and development (*Airbus*), maintenance (*Lufthansa Technik AG*) and the supplying industry, characterized primarily by small and medium-sized enterprises (SME).
Due to the promise of the Senate of Hamburg to expand the factory of *Airbus* in Finkenwerder and "to take all steps in the context of and according to the legal regulations to provide a sufficient extension of the runway"[2] Hamburg gets three production lines from *Airbus*: the body section of the entire Airbus-family, the final assembly of A318, A319 and A321 and together with the cabin equipment a part of the final assembly of the new mega liner A380. About 10,000 employees work at the factory in Hamburg. Thus, Hamburg forms the competence centre for cabin equipment within the *Airbus Industry* and is worldwide the third biggest location of the civilian aerospace industry after Seattle (USA) and Toulouse (France).
Lufthansa Technik AG is one of the market leaders in the sector of aeronautic services and has its main office in Hamburg. It provides different customers in this industrial sector with the so-called Maintenance, Repair and Overhaul (MRO) services. More than 25 subsidiaries in Europe, Asia and the USA occupy approx. 18,000 employees worldwide, 7,000 of them in Hamburg. On the territory of Hamburg Fuhlsbüttel, it offers the complete spectrum of the airplane services: complete overhaul both of Airbus as well as of Boeing samples, jet engines by different manufacturers, development, conversion [retooling] and complete equipment of VIP and business airplanes.
About 300 SME with competences relevant for Aerospace and connected industries are settled in Hamburg. They work particularly in the areas of construction, design and products of the cabin equipment and on board systems. In research and development but also in matter of

[2] Free translation of the authors. For original text see Bürgerschaft der Freien und Hansestadt Hamburg 2004, p.1.

training and qualifying the staff required they cooperate narrowly with the technical universities and work together with educational institutions.
The emergence of an Aerospace industry at Hamburg was not market-driven but dependent on decisions within the Airbus project. From its beginning, the Airbus project was based on political objectives. *Airbus* was founded at the end of the 1960s as a reaction of Western Europe to the U.S. leadership in the area of the civilian aviation. The governments of Great Britain, France and Germany, the three European countries with the strongest aircraft industries in Europe, decided to join together meeting the transatlantic challenge of the US-American market power. The main driver was the wish to absorb a part of the meanwhile expanding demand of wide-body airplanes worldwide. Last but not least, they wanted to counteract the deeply disappointment of the various partial or fully unsuccessful attempts[3] to attain back the market position they had at the pre-war.
Airbus was originally initiated with the act of signing of the famous "Bonn protocol" in September 1967, in which the major aspects of the project's financing and the industrial cooperation between the partners were written down. The costs of development were divided between Great Britain and France (represented respectively by *Hawker Siddeley* and *Sud-Aviation*) each to 37.5% as well as Germany (*Deutsche Airbus GmbH*) with 25%. Germany and France participated each to 12.5% and Great Britain with 75% in the financing of the *Rolls-Royce* jet engine. Two years later Great Britain retired from the consortium due to a quarrel, so that the French and the German governments were forced to make a new commitment about splitting the project's costs by themselves. In December 1970 the Airbus consortium took a legal and organizational institution with the foundation of the Airbus Industrie GIE (Groupement d'Intérêt Economique). This type of enterprise allows the partners, according to the French law, the possibility, to organize the desired close cooperation while keeping their legal independence at the same time. The new organization form permitted in addition the advantages of a solid financing, also without the existence of private equity, and last but not at least an open organizational structure and transparency in the accountancy (Berg et al. 1988, p. 125).
In a year the Dutch airplane producer *VFW-Fokker* and the Spanish enterprise *Construcciones Aeronauticas SA* (*CASA*) also became associated members next to the foundation partners (*Aérospatiale* and *Deutsche Airbus GmbH*, *Hawker Siddeley*). The distribution of tasks in the cooperation was organized depending on a technological potential of the enterprises. The partners took care to let them all have access to the technological pool, won by research and development.
At the beginning of the 70s the prerequisites were set to enable the development and manufacturing of the first Airbus airplane. At the end of 1971 the first A300 were ordered. At first the demand came mainly from side of the national airline companies of the project's official partners: *Air France*, *Deutsche Lufthansa* and *Iberia*. The time of the introduction to the market overlap unfortunately with the world economic crisis of the 1970s, in which the demand for wide-body airplanes was strongly influenced by the rampant oil prices. Thus, for the first time the big orders failed to appear. In the 1980s, Airbus developed under the sign of a strong competition. The enterprise followed the market leaders *Boeing*, *McDonnell Douglas* and *Lockheed* at the fourth place (according to market shares) on the market for civilian airplanes. 1984 a strong competitive pressure was the reason that *Lockheed* has retired from this market after developing a model, which showed similar quality characteristics, like a product brought out to the market by *McDonnell Douglas* at the same time.
Guided by time and the customers' specific requirements, the young enterprise tried to develop a whole number of airplane-families, set up on each other and completing themselves. So the following families arose:

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[3] Just to mention projects like *de Havilland's* „Comet", the „Concorde", developed within a British-French cooperation, the French „Caravelle" or the German „Dornier" that never reached the break-even. For a nice synopsis about different airplane projects, see Przychowski 1972.

- Single Aisle: models with an aisle (A318, A319, A320, and A321)
- Wide Body: models with more than an aisle (A300, A310)
- Long Range: models with more than an aisle and increased range (A330, A340)
- Mega Liner: the star model with two general passenger decks and extreme range (A380)
- Super freight jet: A300-600 ST Beluga

Today the main customers of Airbus are especially Lufthansa, Air France, British Airways, Iberia, and Eastern Airlines (the first American customer) but also numerous Asian airline companies. In comparison with 1989 the number of customers has increased to 204 by 134%. Till 1989 1331 airplanes were ordered and 557 - delivered. The cumulative orders of the enterprise count today 5252 and the cumulative deliveries 3752. Due to enormous engagement of the U.S. government and the gradual promotional programs of the *Ministry of Defence* and the *NASA* in the 1980s and 1990s, the U.S. aerospace industry gained an essential lead. This put the European aerospace industry into a new challenge. With the take-over of *McDonnell Douglas* 1997, *Boeing* improved its competitive position and attained higher market shares. Following a recommendation of the EU commission the Airbus partners reacted on this with the merger of the German *DASA*, the French *Aérospatiale Matra* and the Spanish *CASA* into the *European Aeronautic Defence and Space company* (*EADS*) with headquarters in the Netherlands. Later the *Airbus Integrated Company* (*AIC*) was founded with 80% participation of *EADS* and 20% of the British *BAE Systems*. The new society has its headquarters in Toulouse and employs at the production locations in Germany, Spain, France and Great Britain about 40,000 employees. This association set the prerequisites by developing Airbus A380 to break the monopoly of *Boeing's* model B747 on the market for large-capacity airplanes.

Summing up, the political influence on Airbus refers to public funding, the allocation of production between the locations in the four different countries and political lobbying for selling the airplanes to domestic and international airlines.

For Hamburg, the decision by Airbus to build up a production location served as a initial step for SME with aerospace expertise to look for proximity to this dominant customer and for incumbent SME in other sectors to diversify by building up new aerospace production capacities. With increasing technological progress and internationalisation, new challenges become obvious for the SME:

- increasing consolidation within the aerospace value chain, as the domestic customers are only interested in dealing with system suppliers integrating several elements of the value chain,
- increasing pressure to adjust to international technical norms serving as examination knowledge to assess products and services by suppliers,
- increasing pressure to adjust technologies, as new materials are developed by scientists and new electronic services are available to increase productivity and value added of aircraft production,
- increasing internationalisation of competition, as standardised services and production can be outsourced to low cost locations.

Therefore, threats and challenges to the knowledge managements of SME described in general in section 2 can be identified particularly in the aerospace sector in Hamburg. The next section will take a look at institutional initiatives to help SME to overcome these challenges.

4.2 Institutional initiatives in Hamburg aerospace cluster

Hamburg developed as one of the greatest European metropolises. Modern services in the logistics, media and technology sector stamp its economic power next to industry production

and traditional trade. Important conditions for success are the permanent development and improvements in the institutional environment and its customisation at the complex economy dynamics. The results are various initiatives, cooperation and promotional programs trying to assist SME and override the administrative boundaries. The cluster in Hamburg features particularly within the *Airbus Industrie* special competences on the area of "cabin and on board systems" (Pfähler, 2003). SME work in a close cooperation with research facilities creating solutions for the interior equipment and cabin electronics.

- Hanse Aerospace

Hanse Aerospace e.V. (incorporated association) is an association of small and medium enterprises (SME) in Northern Germany that has been registered in Hamburg. It encompasses near to 100 members with app. 7,000 employees. Different fields of competence along the value chain, such as research and development, design and prototyping, manufacturing, maintenance are represented. Above half of the firms offer common services (51 firms); construction (14) and interior design (11) as much as provision and light equipment (10) embody the next biggest categories.

The main objectives of the association are:

- to represent the interests of the members e.g. in cases of negotiating of general purchase conditions;
- to accomplish advisory services in projects and problems raised by specific international acquirements, such like EASA-certifications (*European Aviations Safety Agency*);
- to coordinate different activities in the region within the aircraft cluster;
- to keep in touch with German and EU-government economic and consultation agencies in order to sensitise them for a variety of specific problems and to feedback them in policies of aircraft matters.

Furthermore, *Hanse Aerospace* offer its members the opportunity to exhibit their products and services on the *Aircraft Interiors* - the most important fair for the aerospace supplier industry in Northern Germany. It has been founded in the middle of the 1990s as an initiative of some of the SME itself in order to partially outsource and bundle the efforts of the business owners in Hamburg and Northern Germany to try to actively contribute on the states' decision process in policies about the aircraft industry sector in the region.

The sector's advantages as a financially attractive growth market were considered newly as a result of a market forecast by *Hanse Aerospace*. At the end of 2004 six enterprises of the aerospace industry in Northern Germany got together and founded *Cabin Systems Holding* (*CSH*), in order to face the challenges of the sector - solid competitive pressure amongst suppliers in taking contracts by the Primes, the long-term engagements in the industry, as if the financial difficulties in getting a capital as a start-up. The members are providers of IT, finance, logistics, and staff services. They aim to be acknowledged on the market as exclusive competence holders of cabin equipment and electronics with the necessary size and range to act as system suppliers. The recruitment of new enterprises shall be carried out purposefully in order to cover the entire performance range of cabin equipment. The organisational structure follow an approach of network of networks, which mean that the participating SME as shareholders of CSH remain independent companies but have the opportunity to cooperate and bundle their business relationships to capital markets and the OEM not only in the aerospace market but also as a supplier for ship cabins, railroad and bus compartments.

- Luftfahrtstandort Hamburg (Aeronautics location Hamburg)

Since 2001 enterprises, universities, authorities, associations and institutions collaborate hand to hand and bundle activities for the promotion of the aeronautics location Hamburg. They

aim to promote it as an internationally competitive centre of the civilian aviation, aeronautical services and air traffic. *Airbus Deutschland, Lufthansa Technik, Hamburg airport, Deutsche Gesellschaft für Luft- und Raumfarht* (*DGLR*), *Verein Deutscher Ingenieure* (*VDI*), *Hanse Aerospace e.V., Hanseatic Engineering & Consulting Association e.V.* (*HECAS*), *Agentur für Arbeit Hamburg (job services), Industriegewerkschaft Metall Küste (trade union), Handelskammer Hamburg (chamber of commerce), Nordmetall (employers' association), Freie und Hansestadt Hamburg* participate in this bottom-up emerged public-private-partnership.
Due to accepted trainings and apprenticeships-organizations and universities with technical and applied focus Hamburg is the nationwide leading education centre in aeronautical engineering. This network offers a lot of job-access possibilities, and the initiative is further trying to expand it. Numerous measures for education and further trainings assure in long run the need of offspring and qualified employees and also the success of the aeronautics location.
Both in R&D and in the qualification processes cross-border cooperation become more important. Consequentially, the initiative closed a partnership with the French regions Midi-Pyrénées and Aquitaine last year. Its purpose is to build up a German-French network between enterprises of the aerospace industry, schools and universities. The intercultural competence of the graduates shall be intensified by exchange of trainees and studying in the area of aeronautics. There are special Partnerships between Hamburg, Toulouse, and Bordeaux universities. These various exchange programs increase attractiveness and quality of the education at the aeronautics location Hamburg but also make the access to professional carriers getting easier for the graduates and intensify the capital mobility. Another main focus of the initiative refers to public relations and informal networking. In the context of public relations, the initiative presents itself on a website and attends to international fairs as well as to national and international network programs. One example in this context is the presence in "Kompetenznetze.de", a website by the German Ministry for Research and Education to present an overview to best practise clusters in Germany. Activities to strengthen informal networking include the emergence of special groups or communities-of-practice for specific topics as well as the organisation of events with topics of general interest and opportunities to come together.

4.3 Hamburg's institutional system – boundary spanning to international knowledge flows?

Table 2 showed several characteristics of effective institutional arrangements to help SME to cope with new challenges on knowledge management. In this section, we will try to take a look, whether these characteristics are met in the case of Hamburg. The first characteristic refers to the scope of technological knowledge and organisations included. These characteristics refer to the necessity not only to include relevant regional market players but also suppliers of scientific and examination knowledge. Within the location initiative, a diversified set of different companies and organisations are included. Informal structures shall help to identify common interests for cooperation. The actual impact, however, depends on individual initiatives. Hanse Aerospace also includes a wide range of SME with different expertise. Again, the impact on actual cooperation will depend on incentives and capabilities of the companies' representatives to take advantage from the possibilities. Up to now, not even within the cabin systems market unique expertise by cooperation has been built up.
The similarity of challenges shall increase the motivation to share knowledge and offer network goods. This prerequisite is clearly given in the case of Hanse Aerospace, as all SME in Hamburg are affected by structural changes in the international aerospace market. The integration of Lufthansa Technik and Airbus as the dominant customers within the location initiative helps to build up a critical mass for qualification and marketing programs. In this context, Airbus is at least partly committed to the success of the initiative by the political objectives to

have a minimum share of German production within the value chain. Thus, Airbus has an interest to increase the productivity at this location, as alternatives are restricted.
The deliveries of the institutions refer to different opportunities for cooperation and information. In particular, the support for international fairs (joint presentations) are helpful to get access to international knowledge flows. The approach to build up CSH as a system house shall also offer opportunities to SME to get access to international knowledge flows, as only the close contact to the OEM and the special requirements of their customers make information on international markets available. Within the location initiative, the cooperation with other aerospace regions improve the access to expertise at these other locations, thus increasing knowledge flows. Furthermore, the public relations might also help to attract companies from other countries
The wide range of opportunities to join informal meetings and exchanges within the institutions in Hamburg has a strong impact on cognitive frames. As the core aerospace industry is characterised by small groups of professional experts coming from a small number of universities and companies, most of the people already know each other. The association and initiative, however, help to extend this core to other groups like SME with only smaller parts of aerospace production and less experience in this industry or scientists or qualification organisations. The commitment is mainly secured by mutual trust within geographical proximity. As most of the companies and individuals are members in most of the organisations within the cluster, any free riding behaviour cause risks of completely losing access to the aerospace market. This aspect of trust also affects the exclusiveness of the institutional good. Without access to the location initiative and association, companies and other organisations hardly get any chance to cooperate within the value chain. Table 3 presents a brief summary of the described observations.

Table 3: Observations within the Hamburg institutional initiatives

Characteristics	**Observations in Hamburg**
Scope of technological knowledge included	OEM, suppliers, research organisations with special focus on cabin systems and materials
Scope of organisations included	Companies, research organisations, universities, professional associations, chambers of commerce, trade unions, employer associations, public administration
Similarity of challenges (belonging to the same value chain)	Common challenges by structural changes in the aerospace value chain
Deliveries	Access to international fairs, international qualification, capital markets, multinational companies
Impact on cognitive frames	Secured by several informal activities
Commitment and monitoring	Secured by mutual trust and geographical proximity
Exclusiveness and barriers to access	Secured by relatively small number of participants with mutual control

5. Conclusions

SMEs face severe challenges caused by internationalised markets and new paradigms of innovation. The example of Hamburg aerospace cluster shows several initiatives to use institutional arrangements as means to help SMEs within this process. It also illustrates the specificities of German institutional development within the medium technology industries, which has always been characterised by cooperation between several associations and public organisations, with Hamburg as a metropolitan case, where relatively wide range of different kinds of institutions can be integrated into a cluster. Keeping these specificities in mind, the approach of CSH to build up a network of networks between independent SME might be a consequential step. The case of aerospace industry with a strong political influence might further help to build up institutions. The sustainability of these activities, however, has still to be proved against the background of intensified international competition.

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