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THE INTERNATIONALISATION OF R&D: HOW ABOUT RESEARCH AND TECHNOLOGY ORGANISATIONS?

-SOME CONCEPTUAL NOTIONS AND QUALITATIVE IN-SIGHTS FROM EUROPEAN RTOS IN CHINA-

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Abstract:

Recently, the internationalisation of business R&D has received much attention. Much less attention has been paid to another group of actors within national systems of inno-vation: namely, non-university research and technology organisations (RTOs). The pa-per aims to conceptualise this very diverse sector and to ascertain how its characteristics influence RTOs' internationalisation propensity. Since China is/ will be one of the principal destinations for R&D-related foreign direct investment, we present empirical findings about five European RTOs having set up rep-resentative offices in China. We conclude by tentatively comparing the internationalisation process between enterprises and RTOs.

Keywords: Internationalisation, R&D, research institutes, China

JEL Classification: D83, F20, L30, L84, O30

1 Introduction

The abbreviation RTO, and the term 'Research and Technology Organisation' is not well perceived in the scientific community, which is a telling sign for the amount of research that has been devoted to this type of organisations. "Voluminous literatures address the evolution of universities and changing practises and structures in industrial research and development. Much less attention has been devoted to understanding the third group of major players in knowledge production that of public sector laboratories" (PREST 2002: 2).

Consequently, this paper[1] tries to tackle this gap in research, in particular in respect to the internationalisation of R&D. Since China's booming economy devotes increasing amounts of funds to R&D and attracts significant amounts of foreign direct investment related to R&D facilities the empirical focus is on the People's Republic.

Hence, the key questions are:

- What are motives for, forms and recent developments of the internationalisation of business R&D and science?
- What characterises RTOs? How do these characteristics influence their internationalisation propensity?
- Why coming to China – what are motives and missions of European RTOs?
- What are differences compared to the internationalisation of enterprises?

The paper is structured in the following way: First, some empirical evidence is provided to shed some light on the magnitude of and reasoning behind the process of internationalisation of (business) R&D and science. Second, a definition and some basic characteristics of RTOs are given. Moreover, we contemplate about the impact of these characteristics on the internationalisation propensity of RTOs. Third, some empirical evidence is provided about the internationalisation of five European RTOs in respect to China. Finally, some (tentative) conclusions and working hypotheses for future work are deduced.

[1] Acknowledgement: This research project has been funded by the Austrian Federal Ministry for Transport, Innovation and Technology. The results have been integrated in the OECD"Review of China's Innovation System and Policy" which is due to be published later this year.

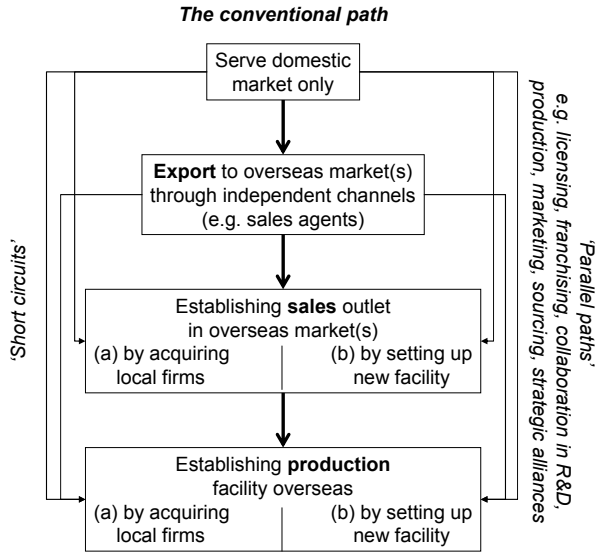
2 Internationalisation of R&D – motives and evidence

To grasp the position of RTOs in a process of internationalising R&D demands for dealing with concepts, which are able to provide answers for the rationales determining these developments. Therefore concepts to explain the motives behind internationalisation and empirically observable patterns of these processes are presented in the subsequent paragraphs.

2.1 CONCEPTS TO APPROACH MOTIVES OF INTERNATIONALISATION

The internationalisation (or globalisation) of production is a well known process which has been taking place for several years. More recently, the **internationalisation of business R&D** can be witnessed, not only to advanced but also to emerging economies. In respect to transnational corporations (TNC) the internationalisation process is well documented. For example, Dicken (2007) has characterised the development of TNCs as a sequential and linear process, whereby an enterprise first serves the domestic market, before it starts to export and/or to license foreign manufacturers. Subsequently, firms will establish a sales outlet, before establishing production facilities in the host market (see Figure 1).

Figure 1: Diverse paths of TNC evolution



Dicken 2007: 116

Once production facilities are established, a need arises to set-up supporting R&D facilities, which will gradually scale up. Dicken (2007) differentiates three generic-types of facilities: A 'support laboratory' that provides technical back-up for production and facilitates the transfer and adaptation of technology from the parent to the affiliate; a 'locally integrated R&D-laboratory' which engages in product design and development for the local market; and an 'international interdependent R&D-laboratory' which has the objective to develop new ideas for the global operations of the TNC and which is more extensively integrated with other globally-based R&D-centres of the TNC than to the firm's production sites within the host country (for a complementary taxonomy see Ronstadt 1977).

Hatzichronoglou (2006: 7) distinguishes following **main forms** of the internationalisation of R&D:

- "Establishing R&D activities by foreign-controlled affiliates in the host country;
- Setting up R&D laboratories abroad by investing countries (countries of origin);
- Creation of joint ventures situated in one of the investing countries or in a third country;
- Co-operation agreements or technological alliances between independent groups belonging to different countries, whether or not they have financial links to each other;
- the various forms of international subcontracting of R&D."

While Dicken (2007) provides rationales for a 'stage-model' of internationalising R&D, Hatzichronoglou (2006) adds a typology of different organisational forms. Even though both concepts are partly overlapping, they are taken as a starting point to approach the addressed research questions.

Further following the literature, one derives with a distinguished set of **motives for internationalising R&D** functions, which traditionally have been carried out at the home base of a TNC. These can be grouped in the following categories (Brockhoff 1998, Gammeltoft 2006, Reddy 2000, UNCTAD 2005):

- **market related**: to adapt products to local needs, to keep track of customer demands and to give technological back up for important production sites;
- **technology related**: TNCs try to tap into foreign science and technology resources;
- **cost related**: not only the labour costs for engineers and scientists vary globally, but also costs for construction, operation and maintenance;
- **human resources related**: firms seek access to a pool of highly skilled (and relatively immobile) personnel – in some industries the supply of high class scientists at the home base might simply not be sufficient to sustain the TNC's R&D efforts;
- **related to technology monitoring**: to monitor new developments in science and technology or to analyse competitors;
- **non-R&D related**: national governments might connect market access to the establishment of R&D facilities (e.g. in pharmaceuticals), or a company might want to improve its image by showing commitment to the host region by transferring R&D functions.

Combining types and motives of foreign R&D facilities produces a dichotomy of the following two types of R&D FDI: units that are concerned with the exploitation of the firm's knowledge stock and units that aim at augmenting that existing knowledge stock of the firm (Kuemmerle 1999). Kuemmerle labels these types of R&D facilities 'home-base-exploiting' and 'home-base-augmenting' FDI.

Following the knowledge paradigm two effects may be considered as driving forces. **Home base exploiting** is responsible for adapting existing products to local needs and transferring knowledge and prototypes from the firm's home location and therefore follows existing production abroad (see also Hotz-Hart, 2000). There is evidence that much of the technology that is developed by MNCs abroad still falls into the core areas of the firms' competence, "suggesting that adaptation and technical support to foreign manufacturing plants continues to be a major explanatory factor" (Cantwell and Iammarino 2003: 4) for the dispersion of multinational R&D activities.

In contrast, **home base augmenting** has the task of extending existing core competencies and of broadening the knowledge base of the firm. Its requirements on a location are fairly different from HBEs. In order to participate in innovative networks, to benefit from spillovers and to tap into local knowledge they need to be located in agglomerations that host a high density of high-class R&D facilities (public or private), service companies and institutions as well as a large pool of highly educated engineers and scientists (e.g. Ivarsson and Jonsson 2003). Furthermore, different locations offer different specialisations, and it is necessary for TNC to 'be there' in order to make use of this localized knowledge. Reddy evaluates this access to "a wide range of innovative stimuli and sources of scientific creativity" (2000: 27) as the key driving force behind the internationalisation of R&D by TNCs.

2.2 PATTERNS OF INTERNATIONALISATION

A recent OECD report (2006: pp. 121) sees three distinguishing features of the current R&D internationalisation: First, it has accelerated its pace, second, it is spreading to an increasing number of countries and third, it encompasses R&D beyond adapting technology to local needs.

Exemplary, Table 1 displays the R&D expenditure of foreign affiliates as a percentage of R&D expenditures of enterprises for the earliest and latest available year in 18 countries. It clearly displays a surge in expenditure for most countries (for similar evidence see INSEAD and Booz Allen Hamilton 2006, UNCTAD 2005). In order to grasp also non equity based forms of the internationalisation (alliances, subcontracting), additional output indicators – such as co-owned patents, domestic ownership of foreign inventions or technology balances – need to be taken into account. All of these indicators similarly point towards an increase of the internationalisation of business R&D (OECD 2006).

Table 1: R&D expenditure of foreign affiliates as a percentage of R&D expenditures of enterprises

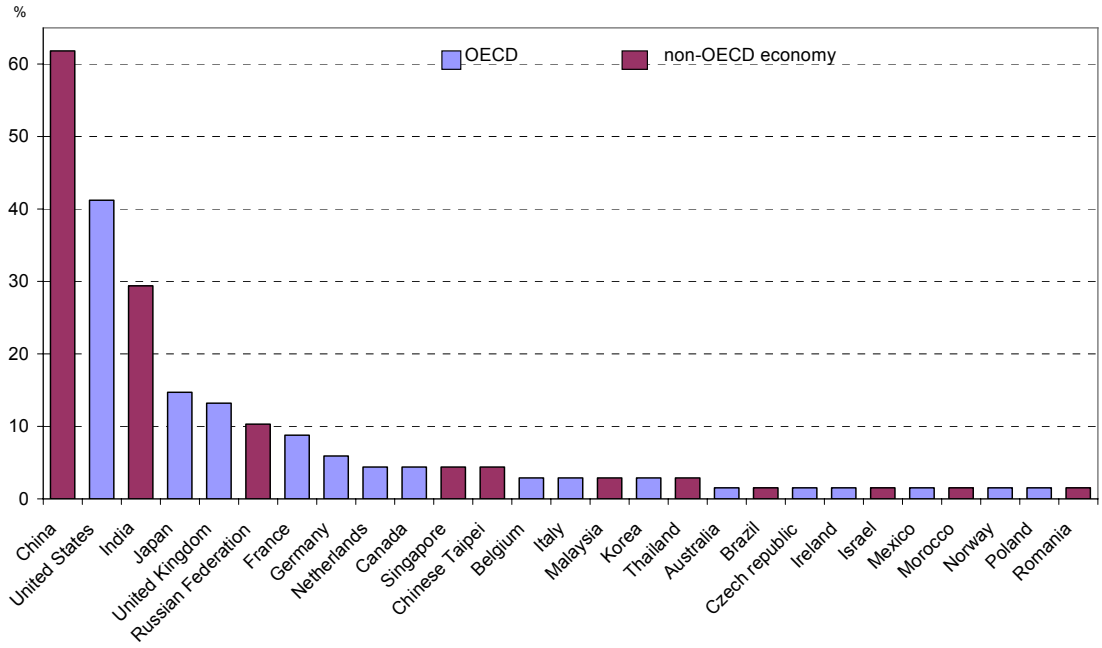
Country	earliest year	%	latest year	%
Czech Republic	1996	18.0	2003	46.6
Finland	1997	13.3	2004	16.4
France	1994	14.2	2003	22.6
Germany	1993	15.9	2003	26.7
Greece	1988	5.3	1999	4.5
Hungary	1994	22.6	1998	78.5
Ireland	1986	61.6	2003	72.1
Italy	2001	33.0	2003	32.1
Japan	1991	0.9	2003	4.3
Netherlands	1997	20.6	2002	31.3
Portugal	1999	18.0	2003	24.6
Slovak Republic	1994	2.2	2003	22.4
Spain	1990	38.7	2003	26.2
Sweden	1990	15.7	2002	34.4
United Kingdom	1994	28.0	2004	38.6
United States	1983	6.4	2003	14.5

OECD, Main Science and Technology Indicators 2006-2

Thereby the internationalisation of R&D is **strongly concentrated** in sectoral as well as geographical terms. Regarding **sectors**, the OECD (2006) shows that most cross border R&D investments is going to the chemical/pharmaceutical, computers and electronics as well as automobile sector. In respect to the **geographical concentration**, there is clear evidence that the internationalisation of business R&D

mainly involves the United States and the European Union as well as – to a lesser extend - Japan (OECD 2006, Veugelers et al. 2005). In 2004 more than 70% of foreign affiliates with R&D as their main activity (based on a sample of 2,600) were located in Western Europe (54%) and the US (21%). South, East, and South-East Asia accounted for about 9%. (UNCTAD 2005, United Nations 2005). Having said this, there are signs of a **deconcentration process**: In 1975 55% of all (surveyed) R&D sites were located in the home country of the enterprise, 31% in Western Europe, 9% in the US and the remaining 5% in other foreign locations. In 2004 the share of R&D sites in home-countries (34%) and Western Europe (28%) decreased whereas the share of the US (16%), China (9%), India (5%) und other countries (9%) rose (INSEAD and Booz Allen Hamilton 2006). Today, 'emerging economies' like China, India or Russia already host a significant amount of R&D centres and are among the most attractive foreign R&D locations (OECD 2006, Thursby and Thursby 2006; Figure 2). As a consequence '**emerging economies**' can be considered as the **beneficiaries** of these deconcentration process, especially large economies such as China and India (Narula and Zanfei 2004, Reddy 2000, UNCTAD 2004, 2005). It can be expected that this process will continue: the *Economist Intelligence Unit* found in a survey of 104 managers a strong tendency to locate R&D facilities in these countries. Asked where they will spend most money on R&D outside their home country within the next three years (basis 2004), 39% of the respondents named China, 29% the US, 28% India, 24% the UK and 19% Germany (EIU 2004).

Figure 2: Most attractive foreign R&D locations (% of responses)



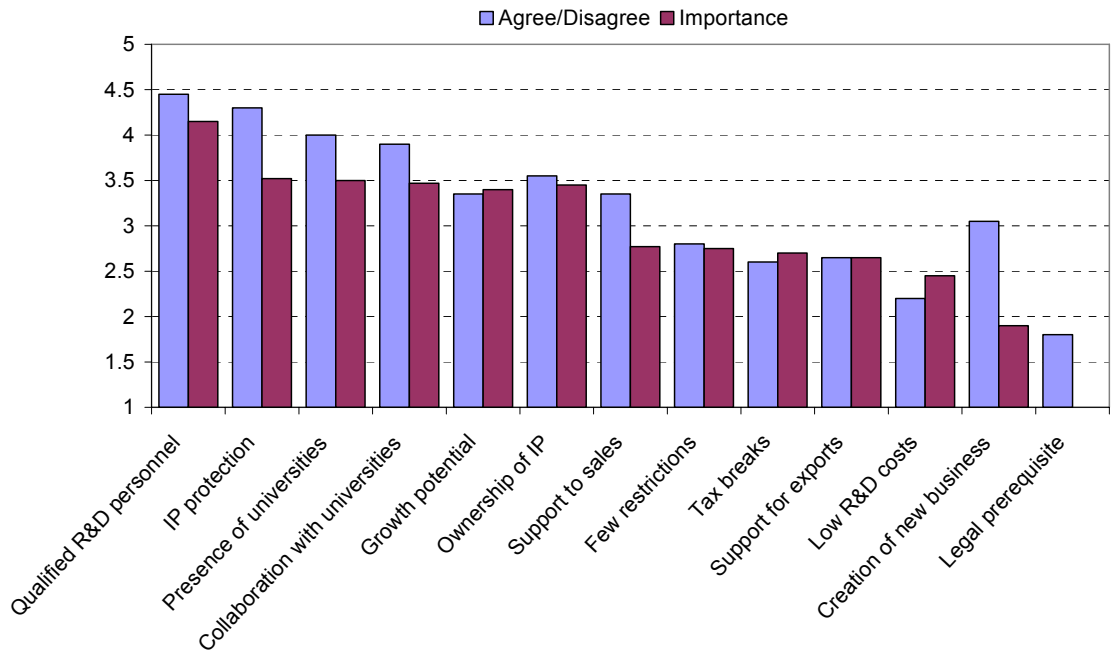
OECD 2006: 135 based on UNCTAD 2005

Still, **R&D** is the **least internationalised enterprise function** (UNCTAD 2005). Despite a lack of comprehensive data on this process, different pieces of empirical evidence shows that there is a clear tendency of an **increase in the internationalisation** of R&D (see Edler et al. 2002, Karlsson 2006, Serapio et al. 2004, UNCTAD 2005, Zedtwitz and Gassmann 2002

A survey of 250 multinational enterprises (Thursby and Thursby 2006) resulted in some interesting insights about these internationalisation activities:

- The major driver for establishing R&D facilities abroad are expansion (more than 75% of responses) and support of production (more than 50%). Relocation plays only a minor role (< 30%).
- New science is rather performed at home or in other developed economies than in emerging economies.
- Four factors have the strongest impact on the location decision: Output market potential, quality of R&D personnel, university collaboration and intellectual property protection. However, there are clear differences for setting up R&D facilities in developed and emerging economies. In emerging economies growth potential is most important followed by the quality of R&D personnel, R&D costs and universities (expertise and collaboration opportunity). In developed economies (or the home economy) qualified R&D personnel is most prominent, followed by IP protection and the quality and availability of universities for collaboration (see Figure 3 and Figure 4).

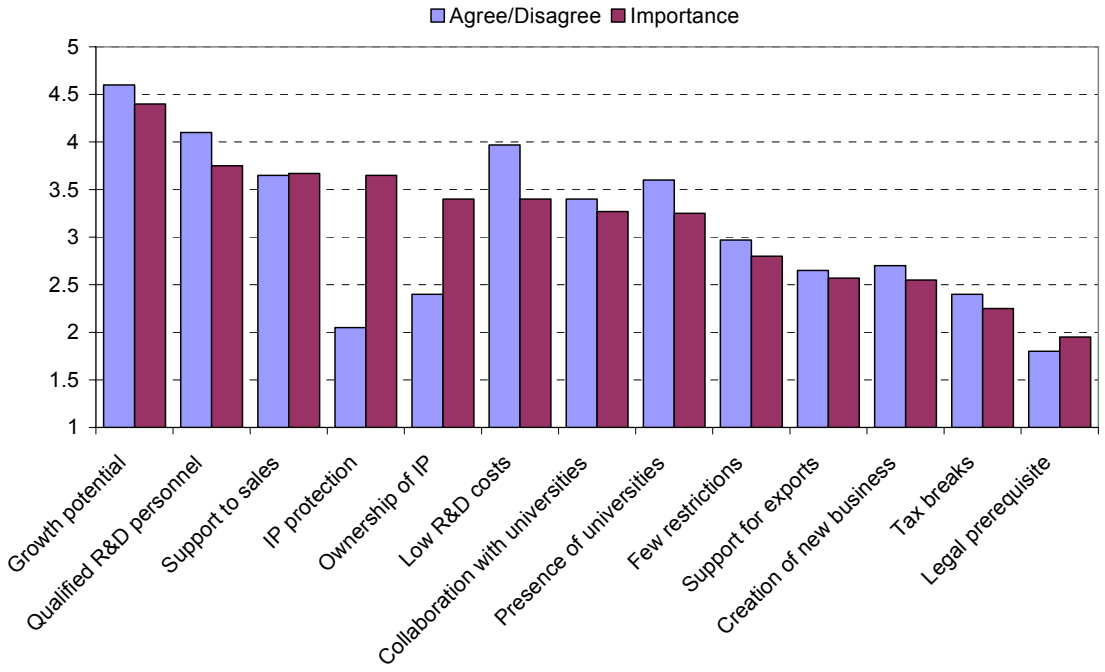
Figure 3: Factors in locating in developed countries[2]



Note: a 5-point scale is used where 5 is strongly agree and 1 is strongly disagree, likewise 5 is extremely important and 1 is not important at all. OECD 2006: 139 based on Thursby and Thursby 2006

[2] "Respondents were asked two questions about each of a set of factors that might or might not have been relevant in selection of the site. First, respondents were asked whether they agreed or disagreed with a statement about a factor that might have led them to locate in the country. They were then asked how important or central the factor was in the deliberations on whether to locate in the country" (Thursby and Thursby 2006: 21).

Figure 4: Factors in locating in developing or emerging economies



Note: a 5-point scale is used where 5 is strongly agree and 1 is strongly disagree, likewise 5 is extremely important and 1 is not important at all. OECD 2006: 139 based on Thursby and Thursby 2006

Consequently, RTOs are important factors for the location decision, because they are potential collaboration partners and sources of knowledge. In this, they are more important in developed economies, but still highly relevant in emerging economies. Moreover, there is a tendency of rather 'improving familiar technologies' than 'creating new technologies' in R&D facilities in emerging economies (Thursby and Thursby 2006). Presumably, this results in different demands for R&D services provided by RTOs. Even though the results "indicate that firms increasingly move more basic and applied research to emerging countries than development and customisation work" (OECD 2006: 138).

Regarding the **internationalisation of academic research** Wendt et al. (2003: pp. 68) distinguish between **mobility of researchers** (e.g. working abroad permanently/ temporarily; for training; for collaboration) and different types of **research collaboration** ranging e.g. from informal contacts, conferences to collaborative projects, sharing of infrastructure or data, participation in foreign funding programmes to the establishment of subsidiary laboratories in a partner country.

Main motives for the internationalisation can be seen in

- direct benefits: "allowing the research to be performed or applied at a higher quality, with a broader scope, more quickly or more economically" (Georghiou 1998: 620), and
- indirect benefits like "enhancement of reputation, access to further research funds, political, economic or social benefits" (ibid.).

Wendt et al. (2003: 65) point out that "competition provides a push towards internationalisation", since universities and RTOs compete for good researchers/ students and research funds. Since international collaboration is seen as an appropriate measure to keep at the knowledge frontier and to further its (international) reputation, which in turn increase the likelihood to attract the 'best' human resources

and additional research funds. Hence, internationalisation is often perceived as a quality indicator per se.

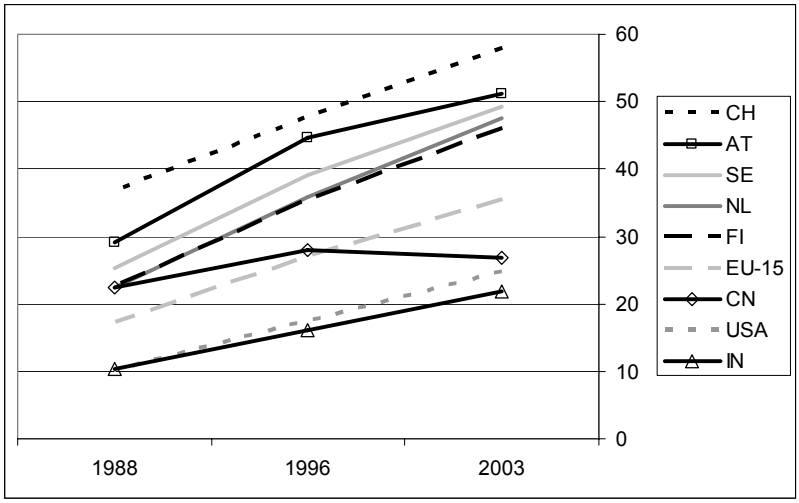
Just like business R&D academic research experienced a marked increase of internationalisation in the previous two decades: Vincent-Lancrin (2006) reports about a rising **mobility of scientists** (e.g. inflows to the US increased by 49% between 1994 and 2005; but no systematic information on other countries is available), and internationally **co-authored** (or collaborative) **scientific articles** (see Figure 5). At the same time the number of countries with which each country has scientific collaborations enlarged as did the number of citations of foreign scientific articles. Moreover, the **share of foreign funding** of academic research has tripled between 1981 (2%) and 2003 (6%), which – at least in Europe – is partly caused by the European Union Framework Programmes (for additional evidence on Germany see Edler et al. 2007).

Despite (or rather because of) the fact, that we were unable to find information on direct investment by academic organisations in foreign laboratories (subsidiaries), it can be assumed that this still a very rare case und the internationalisation of science is rather driven by 'lower-threshold' activities.

According to Edler et al. (2007) it can be expected that the internationalisation process (based on a German survey) will go on, even though at a slower pace than in previous years. Moreover, the United States will continue to be the most important collaboration partner, but that East Asian countries, most notably China, will become increasingly important.

What are important results from this research concerning RTO's perspectives? In summary, it could be argued that not only cultural and incentive aspects differ between science and industry (e.g. commercialising vs. publishing; see Dasgupta and David 1994, Kaufmann and Tödtling 2001), but also the way of R&D internationalisation. It seems that academic research (for now) relies much more on 'soft' measures such as joint research, publications, mobility than on 'hard' measures such as R&D related foreign direct investment. Consequently, it is interesting to see how RTOs – being situated at the nexus between these two systems – behave. Moreover, RTOs are almost not analysed in respect to their internationalisation processes and it needs to be asked, whether RTOs behave either like academic or industrial organisations, or if there is a reasonable argument for treating them as a separate category in the internationalisation process of R&D.

Figure 5: Coauthorship share of selected countries on international S&E articles (1988-2003)



Own calculations based on NSB 2006 using figures of the Science Citation Index and Social Science Citation Index

3 A strange animal: What are RTOs?

In the following chapter we try to figure out the characteristics of RTOs in order to find some evidence for their special status. For this, especially the particular relationship to governments will be be addressed as well as their funding mix and empirical evidence on their internationalisation patterns.

3.1 CHARACTERISTICS OF RTOS

It is a challenging task to give a clear definition of a RTO, because these organisations vary widely in respect to their characteristics: They might be public, semi-public or private; sometimes they operate as private companies but are owned by a public body. Some operate on a commercial basis, while others have a non-for profit character. They may receive funding from membership subscriptions, fee-for service activities, government core funding, contracts for public grant-funded research or competitive contracts from firms or governments. While many are technology-oriented others provide services in social sciences or economics. RTOs do basic or applied research, some do both. Some offer technology transfer and even implementation support while others are into certification and standardisation (EURAB 2005, Farina and Preissl 2000, Hales 2001).

Some wide definitions of RTOs even include universities. However, a narrow perspective is more common, which distinguishes RTOs from private manufacturing companies, knowledge business services (KIBS), universities and academies of science and engineering (Farina and Preissl 2000, Hales 2001, Standke 2005). Nevertheless, many functions and services overlap.

To our knowledge two major projects have specifically considered (European) RTOs:

- First, "Research & technology organisations in the service economy - Knowledge infrastructures, innovation intermediaries & institutional change" (RISE), a two year research project funded by the European Commission that terminated in November 2000 (see RISE 2001).
- Second, the study "A Comparative Analysis of Public, Semi-Public and Recently Privatised Research Centres" (see PREST 2002, henceforth PREST-project) that created a database of European non university research institutes, elaborated more than 50 case studies and EU-15 (excluding Luxembourg) country reports.

For the RISE-project Hales (2001:4) elaborated a basic, **'stereotypical' definition**: "RTOs are organisations with significant core government funding (25% or greater) which supply services to firms individually or collectively in support of scientific and technological innovation and which devote much of their capability (50% or more of their labour) to remaining integrated with the science base". Subsequent work resulting out of the project chooses a softer definition: RTOs are "publicly or partly publicly financed research institutes that contribute either directly or indirectly to systems of innovation" (Preissl 2006: 133; Preissl 2000). The pragmatic approach by the working group around PREST did not consider a detailed definition, but included national (as opposed to international), non-university public or semi- public research institutes as well as institutes from the non-profit foundation sector "where government was the major customer or the driving force behind their creation and existence" (PREST 2002: 7).

The European Association of Research and Technology Organisations (EARTO) considers its members as organisations „which as their predominant activity provide research and development, technology and innovation services to enterprises, governments and other clients“ (EURAB 2005: 1).

According to Preissl (2006: 134) all RTOs share two **common characteristics**: first, they display a combination of public and commercial sources of funding, and second, they provide a combination of academic and applied research.

Table 2: Typical functions of RTOs

	Function	Examples of activities	Rationale(s) for RTO role
A	Fundamental/ strategic research	• Fundamental research in particular in areas considered to be of strategic importance, e.g. defence/security, nuclear energy, public health. • Long-term studies	• Improbability that enterprises or universities would undertake the work in sufficient breadth/depth, inter-disciplinarity, with sufficient continuity. • Need to combine basic and applied work and to ensure "knowledge integration", i.e. marrying knowledge from own and other sources (cf mission orientation of RTOs). • Scale of the investment required for critical mass (people, facilities, etc.). • Security (in strategic or sensitive areas). • Specialised training and skills (perhaps a benefit rather than a rationale).
B	Technological support to economic development	• Contract research services to industry • Long-range technological research[1] • Technology "extension" • Support for SMEs	• Compensate market imperfections related to cost and risk • Accelerate and broaden technology diffusion.
C	Supporting public policy	• Fundamental and precautionary research, e.g. environmental policy, public health, food safety, sustainable development • *Ex-ante* policy design and impact analysis • *Ex-post* surveillance and monitoring of the implementation of policy, e.g. pollution, seismic survey • Expertise	• Impartiality (including the need to separate monitoring and control functions from advocacy functions) • Requirement for resource-/time-intensive expertise (i.e. more than occasional or one-off expertise) • Responsibility and accountability
D	Technical norms, standards	• Pre-normative research Implementation monitoring, e.g. metrology • Certification (and certification of certifiers)	• Impartiality • Security based on independence
E	Constructing, operating and maintaining key facilities	• Big infrastructure (e.g. accelerators, research reactors, botanical gardens, large computing facilities). • Large, unique, dangerous etc. collections. • Large, long-term data collections	• Cost beyond the resources of other players • Security and safety (physical concentration, accountable management)

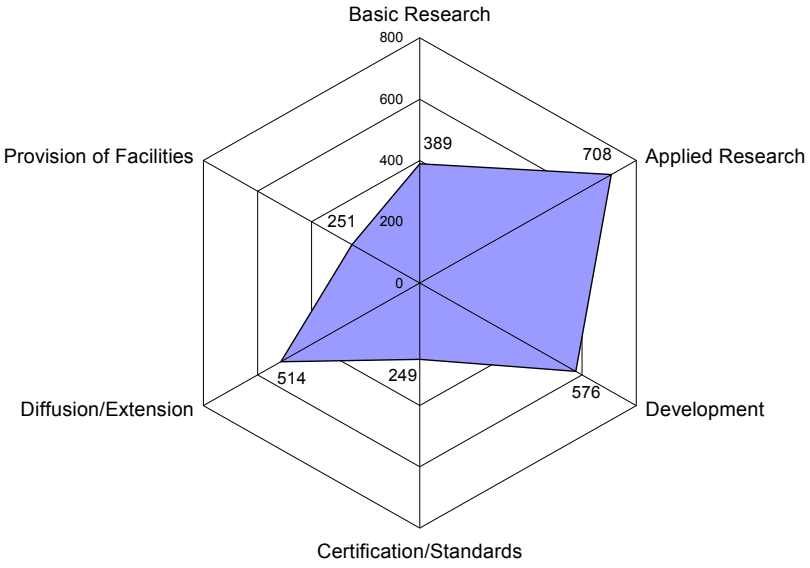
1 i.e. speculative development of technologies which it is hoped will prove to be of major practical significance in the longer term (e.g. ten-year time horizon). *EURAB 2005*

In order to get hold of this 'strange animal' it is not very helpful to try to characterise RTOs in terms of public vs. private or commercial vs. non profit nature due to the diversity within the sector. Rather, **functions** typically performed by RTOs and the underlying rationale should be contemplated (EURAB 2005) (see Table 2). One might add to this typology that RTOs also play a significant role in (further) qualifying university graduates/ young researchers by offering PhD or post-doc positions.

To get an idea about the characteristics of the RTO population in Europe both mentioned studies collected data. The PREST-project database includes some 770 institutes, the RISE project surveyed some 223 RTOs (in Germany, the Netherlands, Norway, Portugal, Sweden and the UK). As an additional indication the EARTO with its about 100 members may be taken into account. According to EURAB (2005) the RTO sector accounts for approximately 14% of total R&D expenditure (GERD) and for about 40% of total government expenditure on R&D (GOVERD) in the EU-15.

The PREST database shows that almost all of the 769 considered European RTOs carry out applied research and many contribute to development and diffusion. Even though basic research is not prevailing it still seems to be relevant for many institutes (PREST 2002; Figure 6).

Figure 6: Frequency of different function of European RTOs (in 2002)



PREST 2002: 17

Recent trends in the sector relate mainly to a 'KIBSification' of RTOs. This is caused by:

- decreasing shares of public funding, especially in 'institutional' core-funding and change towards 'functional' targeted contracts and programmes,
- demand by public owners/ sponsors for a more direct contribution of publicly funded institutes to industrial innovation, and
- demand by industry clients for more comprehensive innovation services (Hales 2001, Preissl 2006: 135).

As a result many RTOs have increased their service/ industry orientation while reducing their contributions to (academic) science. Hence, they get into a situation were they frequently compete with KIBS about contracts, especially since these participate increasingly in the market for public contracts and funding. Furthermore, a trend towards a more international orientation can be observed (ibid.). It can be assumed that the internationalisation for European RTOs has mainly a European dimension because of EU research funding (Framework Programs). In addition to competition from KIBS and other (international) RTOs (in the European arena), RTOs also face competition from universities which seek access to external (programme) funding due to a redefinition of their role, an increase in autonomy and a decrease in core funding in recent years (Yelland 2007) (see Figure 7).

3.2 INFLUENCE OF GOVERNMENTS ON RTOS

"RTOs originally were creatures of policy" (Hales 2001: 66) addressing deficits in national or regional innovation systems and hence are subject to (a certain share of) public funding and government control. Until today governments exert their influence on RTOs via public funding and governance arrangements.

In terms of funding, RTOs rely on a **funding mix** including public and private sources (Table 3), which is a result of their **hybrid character**. On the one hand, they generate income on the market offering services and capitalising on know-how just like private enterprises (e.g. KIBS). On the other hand, they qualify for public funding, because they provide public goods such as basic research and academic publications, and support public innovation policy by facilitating technology transfer from science to industry and offering technical support especially to small and medium sized enterprises (SME) (Hales 2001). Consequently, the usual market and/ or system failure arguments justifying public funds/ subsidies for R&D and knowledge creation hold for – at least – some aspects of RTO activities (Farina and Preissl 2000). Hereby, the mode of funding has clearly changed in recent years: institutional core funding has experienced severe cuts whereas programme based funding has been extended (Hales 2001). This funding mix might lead to a situation which KIBS consider as unfair competition if RTOs cross-subsidies their market-oriented activities with their public funded activities.

Table 3: Funding mix of RTOs

Public funding/ income	Private funding/ income
• Institutional core funding • Programme funding to develop specific capabilities • Programme funding to promote services that RTOs offer to certain segments of the industry (e.g. technology transfer to SMEs) • Competitive contracts funded within broad programmes (e.g. national funding agencies, EU Framework Programs)	• Contract research for enterprises • Service charges (e.g. for using facilities, providing testing/ certification etc.) • Intellectual property transactions (e.g. licensing) • Sales of technology products • Subscription funding from membership base

based on Hales 2001: Appendix 1

Moreover, several mechanisms exist how **governments steer or regulate** RTOs: For example, by public ownership, direct control, a charter, a franchise or service agreement, formal stakes in the management (e.g. nominating board members) as well as the organisational inclusion in the civil service (Hales 2001). The survey by PREST yielded following results: Ownership by the central government and by a non-profit foundation are by far the two most common ownership structures (Table 4). Most RTOs are accountable to either an independent foundation/ regulator or a public organisation/ agency.

The PREST-project concludes that "most research centres today operate at arms length from government" (2002: 15).

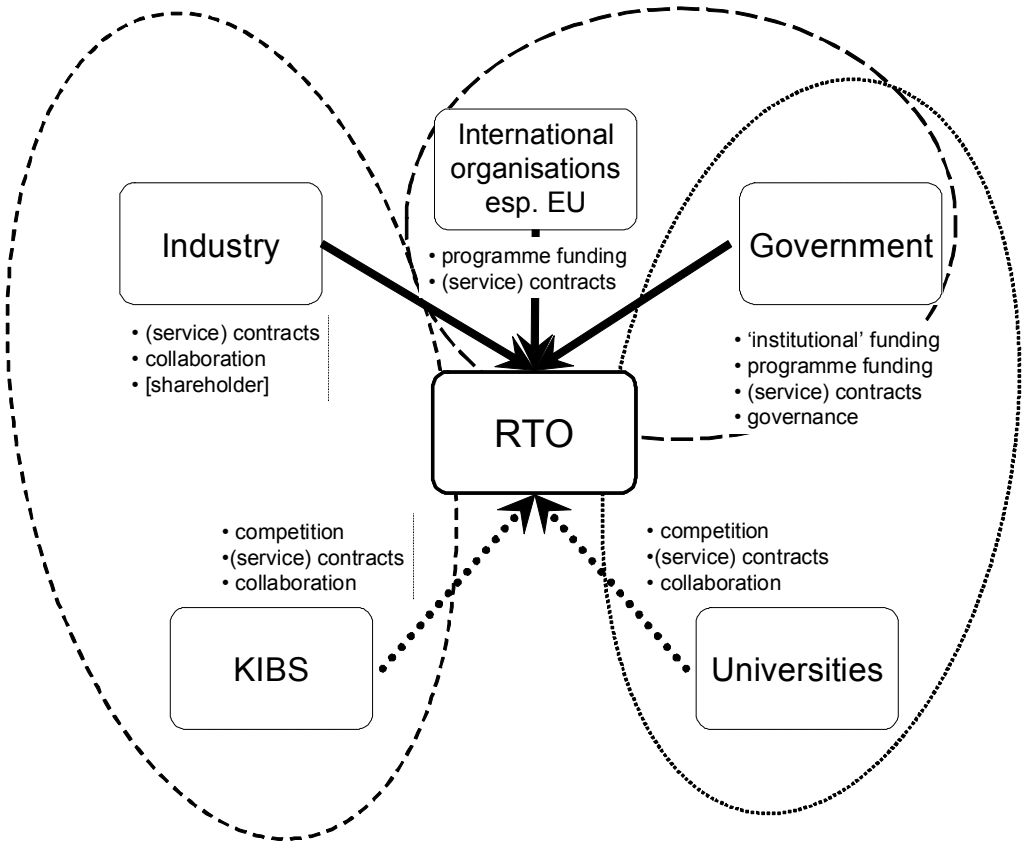
Consequently, governments have several channels of excising their influence on RTOs: as clients, funding agencies, owner, share- or stakeholder. At the same time, RTOs operate (partly) in competition (as well as cooperation) with KIBS and universities, which increasingly enter the market for external R&D funds due tight public budgets, organisational autonomy and respective incentives for scientist (see Figure 7).

Table 4: Ownership and Governance of RTOs (in 2002)

Ownership			**Governance**		
	No.	%		No.	%
Central government	340	44.2	Accountable to foundation or		
Not for profit foundation	321	41.7	regulator	289	38.1
Private sector	56	7.3	Accountable to shareholders	86	11.3
Regional or local government	31	4.0	Branch of government	130	17.2
University	6	0.8	Independent public organisation/		
Other	16	2.1	agency	253	33.4

PREST 2002: 12 & 15

Figure 7: Organisational environment of RTOs



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3.3 INTERNATIONALISATION OF RTOS

After presenting arguments for treating RTOs as unique organisations within the R&D system, we will now focus on differences in their internationalisation behaviour.

To our knowledge there is little empirical evidence on the internationalisation by RTOs. The somewhat outdated results of the RISE-project are displayed in Table 5. It underlines that most RTOs in Sweden, Germany, the Netherlands and the UK have a very low to low 'international business orientation' measured in a synthetic indicator including research contracts from foreign clients and the establishment of branch/ representative offices abroad[3] (Preissl 2000: 58).

Table 5: Internationalisation of RTOs (Survey by RISE-project)

	very low	low	medium	high
Germany	66	21	10	3
Netherlands	29	52	14	0
Sweden	42	37	21	0
UK	33	67	0	0
Total	**170**	**177**	**45**	**3**
%	**43.0**	**44.8**	**11.4**	**0.8**

Preissl 2000: 61

A recent survey of the internationalisation of public funded research organisations in Germany (including 64 universities and 116 institutes of four RTO umbrella organisations[4]) found that:

- In general, RTO researchers display a lower **international mobility** than scientists at universities. However, RTOs employ a higher share of foreign researcher than universities.

- The degree of internationalisation in the **RTO sector** is **very diverse**: while the more basic research-oriented Max Planck Society has a very high degree of internationalisation the applied research-, industry-oriented Fraunhofer Gesellschaft is least internationalised.

- 57% of all RTOs possess a **unit** responsible for internationalisation; 39% formulated an explicit internationalisation **strategy**.

- The share of **foreign industry clients** is low. Even though it is the least internationalised RTO in the sample, Fraunhofer has the largest share of foreign industry clients (45% of all institutes report that more than 10% of all industry-projects include foreign partners). However, the authors conclude that even this share is low considering that foreign affiliates account for 26% of business R&D in Germany.

- 30% of all universities and 16% of all RTOs have at least one **research site abroad**. The interviewees do not foresee a very dynamic growth in this respect – of the organisation without

[3] Measuring research contracts from foreign clients 1999, growth of share 1995-1999, expected growth and number of established branch/ representative offices abroad. Individual scores were assigned to each category of each variable resulting in a maximum score of 7 and a minimum score of 0. From these five intensity classes were deduced: very low, low, medium, high, very high (Preissl 2000: 128).

[4] Helmholtz Association, Fraunhofer Society, Leibnitz Association and Max Planck Society

a foreign R&D site only 6% of the universities and 3% of the RTOs plan to establish such facilities.

- Of all **cooperation partners** (countries) China is currently considered as the fifths important partner (behind US, France, UK, and Italy) by German RTOs. Asked about the growth in importance of the individual partners, China ranks first.

- The top five **motives** for the internationalisation by RTOs are: access to globally available excellent knowledge, access to (EU or other international organisation) funds, reputation, inspiration for new research topics, and utilization of complementary know-how and methods. It strikes, that (only) Fraunhofer ranks the acquisition of contracts from foreign clients among the top 5. "Cost advantage through foreign partner" is considered of least importance.

- The top five **impacts** for RTOs are an increase in the international reputation, extension of scientific contacts, rise in research competence, increase in international publications, and acceleration in the production and use of new knowledge. Again, cost reduction due to the utilisation of foreign infrastructure or know-how has the lowest impact of all factors.

- Asked about **problems for their home innovation system** caused by the internationalisation 24% of the RTOs named brain drain, 19% know-how drain, 15% that research topics are not appropriate for the German market and 14% that foreign firms might benefit too much.

- In respect to **problems for the RTOs themselves** the survey shows following ranking: 24% of all institutes regard an uncertain foreign IPR situation as a problem, 14% strengthening foreign (scientific) competitors, 12% stronger IPR restriction than in national projects, 12% brain drain and 5% a weakening of domestic collaborations.

- In summary, 54% of all RTOs report that the **benefits** of internationalisation are greater than the associated costs. Remarkably, only 32% of the Fraunhofer Institutes see a net-benefit.

Another recent study dealing with general developments of European RTOs (Hofer et al. 2007) reports about increasing internationalisation in terms of the number of international projects and funding. However, still the majority of RTOs fulfil a national or regional mission and there are only few signs of more intense internationalisation, since only few RTOs have foreign direct investments. Consequently, RTOs seem to follow the usual path of having exports of services first, subsequently followed by sales and marketing offices and R&D facilities. Currently, only few larger RTOs have already reached the second and third level of this process. Having said this, 80 per cent of the interviewees expect a growing share of contracts with foreign clients. In respect to the driving forces of internationalisation the study revealed that new customer relations and the extension of the knowledge base are most important.

Based on these findings, it can be concluded that the majority of RTOs are still in an infant stage regarding internationalisation. Even though many of them have some form of official internationalisation strategy, the focus seems to be on (academic) collaboration, publication and informal exchange. The acquisition of foreign clients – especially industry clients – and the establishment of R&D facilities abroad is still not a common internationalisation activity.

These characteristics induce some implications fort he internationalisation propensity of RTOs. Due to their **hybrid character** ('public science' vs. 'private service') RTOs could be expected to display the scientific as well as business type of R&D internationalisation. Theoretically, RTOs should be prone to the internationalisation of their (R&D-service) activities due to similar reasons as enterprises:

- RTOs might see the need to follow their industry clients' R&D activities abroad;
- RTOs might like to exploit market opportunities in emerging markets utilising their core competencies;
- RTOs might want to tap into localised pools of knowledge to augment their competencies;
- RTOs might want to utilise the availability of a large and inexpensive scientific labour force (especially in emerging economies) to reduce costs for R&D and consequently speed up their activities by employing a larger workforce.

These reasons reflect the business rather than the academic perspective of RTOs and thus demand 'higher commitment' activities such as approaching foreign (based) clients and setting up facilities abroad. Thereby, it could be assumed that RTOs follow (to some extent) a sequential trajectory similar to the internationalisation process of TNCs (see Figure 1). However, the following particularities might pose an obstacle to the internationalisation: Since RTOs were initiated by (national) policy it's a moot question whether they fit in an internationalised context: "RTOs have been designed to serve the purposes of national industries in a national political context. This casts doubts on their effectiveness in an international setting" (Farina and Preissl 2000: 22). Moreover, there are concerns if the proximity to national policy impedes internationalisation:

- RTOs rely to a significant amount on public (institutional or programme) funding. Governments sponsor RTO activities because of a market and/or system failure argument. They want to see RTOs contributing to the generation of innovation relevant know-how and technology transfer to e.g. domestic SME in order to improve the quality of the national innovation system and to contribute to national productivity (growth). As a consequence, governments might consider RTOs as a 'national treasure' and be sceptical about the idea of internationalisation activities, because theyr are afraid of know-how drain and strengthening 'competitors'.
- RTOs are subject to intense government influence through governance/regulation resulting in a limited autonomy in respect to the strategic decision to internationalise. Due to the reasons specified above governments might be reluctant to support internationalisation activities.

As a result, the funding structure exercises a strong incentive for RTOs to focus on the national, and – in Europe – EU (Framework Program) market. If they intent to set up facilities abroad, it seems that they would need the support or at least approval of their 'shareholders' – including national government. In summary, RTOs have quite heterogeneous starting points and functions, they heavily depend on and are embedded in national and regional innovation systems. Because of this, they are steered to a certain extent by governments, which consider internationalisation useful, only if it provides added value to the RTOs' core functions and their respective innovation system. Up to now internationalisation of R&D is not very common for RTOs, but a topic increasingly addressed and tackled.

4 Case Studies: European RTOs in China

In the previous chapters we sketched a general picture about the internationalisation of RTOs. In the following a few case studies will be presented which provide insights in the internationalisation attitude of European RTOs with respect to special case of China.

When regarding China as a potential destination for internationalisation efforts by RTOs, it has to be borne in mind, that

- China seems to be of major interest for RTOs (as indicated by Edler et al. 2007) and to R&D related business FDI (see 2.2);

- business R&D in emerging economies tends to be less devoted to new technology (Figure 4), which might limit the scope for the RTO collaboration with existing industry partners establishing R&D facilities abroad. Consequently, entering the Chinese market might rather be an expansion towards Chinese industry clients;

- a frequently cited argument for doing (business) R&D in emerging economies like China is to reduce costs (see 2.2). Albeit, this was not named an important motive for the internationalisation of RTOs (see Edler et al. 2007).

Studies on **R&D activities of TNC affiliates in China** show that at the moment the majority of R&D work is still focused on adaptation, development and incremental innovation targeted at the Chinese market (Berger and Nones 2008, Berger et al. 2007, OECD 2007, Schwaag Serger 2006, Zedtwitz 2004). However, foreign firms start to upgrade and "setting up innovative or global R&D operations in China" (Schwaag Serger 2006: 245) and "multinationals increasingly trying to integrate their R&D organisations in China into their global research networks […] in an experimental mode and very cautiously" (OECD 2007: 20). Main motives are: proximity to market and production, availability of relatively high-quality and low cost human resources, FDI-friendly 'carrot and stick' policies ('market for technology strategy') by the Chinese government as well as presence in a market which develops own national technical requirements and standards in several high-tech fields. Moreover, peer pressure ('follow the herd') plays a certain role. Major barriers are seen in the lack of locally developed innovative and new products, due to overcapacity and uncertain demand, lack of experienced/ qualified personnel in certain sectors, weaknesses in the institutional infrastructure (legal uncertainties, IPR regime), intense competition and high employee turnover, and a technology and R&D gap between foreign and domestic firms which limits strategic partnerships. Moreover, most science-industry collaborations are still at an initial and immature stage (OECD 2007).

This chapter constitutes a first, explorative and qualitative study to enquire **how and why European RTOs enter the Chinese market**. It is based on structured interviews with representatives of four Chinese subsidiaries of European RTOs. All interviews were conducted in spring 2006. The group of interviewed foreign research organisations includes three public research organisations from Europe, namely Fraunhofer Gesellschaft (Germany), VTT Technical Research Centre of Finland and IMEC (Belgium); as well as one umbrella organisation of the national research laboratories in Germany

(Helmholtz Gemeinschaft). In addition, the Dutch research organisation TNO has been interviewed at its headquarters in autumn 2006.

4.1 FRAUNHOFER GESELLSCHAFT (FHG)

FhG from Germany is – according to its own information – the largest organisation for applied research in Europe. It employs about 12,500 people in 56 institutes and has an annual turnover of about EUR 1.2 billion (2006). About one third of the total budget is provided as basic funding by the state while the remaining two thirds are acquired through industry- and publicly financed research contracts (FhG 2007).

FhG has the longest history in China of the interviewed RTOs. Already in the early 1980s FhG signed a cooperation contract with the Chinese Academy of Science. In 1999 FhG opened the main office in Beijing. Today, there are altogether four offices in China. Besides the main representative office, the Institute for Information and Data Processing (IITB) opened an office in 1996, the Institute for Material Flow and Logistics (IML) established a representative office and a local company (Beijing DO Logistics Technologies Co., Ltd.) in Beijing in 2004, and the Institute for Reliability and Microintegration (IZM) has been represented by an office in Shanghai since 2002.

The main representative office is staffed with four persons. Its current mission is twofold:

- First, to acquire applied research contracts from Chinese firms which FhG works on in its institutes in Germany.

- Second, to facilitate Scientific and Technical Cooperation projects (Wissenschaftlich-Technische Zusammenarbeit). These '2+2 projects' are agreed upon and financed by the German Federal Ministry of Education and Research and the Chinese Ministry of Science and Technology. Each project is carried out by one research and one industrial partner of each country.

In the beginning, the latter projects dominated and were essential in order to build networks and a reputation in China. Nowadays the first type of projects prevails. In addition, the office also supported German SMEs to establish operations in China on behalf of the German Ministry of Economics until 2003.

The main industry customers for applied research in China are domestic High-Tech companies in the fields of IT, material sciences, microelectronics, laser and logistics. Most of these firms are so called New Technology Enterprises which are either spin-offs from or privatised ministerial research institutes. Contrary to the majority of Chinese companies who lack the capabilities to source R&D services, the interviewee stated that these firms have the knowledge about new technology, the willingness and the funds to contract research projects to a foreign RTO.

Up to now, FhG contracted more than 10 industry projects in logistics, about 4 in laser technology, 3 in microelectronics and 3 in information and data processing.

The motivation for the establishment of the office was related to the anticipated economic dynamic in Asia and especially in China (FhG also operates offices in other Asian countries such as Indonesia, Japan, and Korea) and the market demand for technological development. The objective of the office in terms of industry projects is mainly to provide analyses about market demand and support the inter-cultural joint research, especially at the initial stage (trust-building, mutual understanding etc.). Moreover, the office acts as a listening post to scan the developments in promising science sectors in China (e.g. biotechnology).

The question if FhG should start carrying out R&D in China in order to utilise the pool of human resources at low costs has been discussed within Fraunhofer, but the society reached the conclusion that it is not yet necessary to have this kind of activities. R&D work at FhG in Germany is fairly cost efficient and benefits from the grown structures. Hence the interviewee does not see the need to either build up or shift R&D work in/ to China. However, the decision might be changed in the long run if the demand from China increases markedly.

According to FhG, the market for applied contract research is still in its infancy in China. There are only few foreign and domestic RTOs. Actually, the number of domestic organisations that carry out applied research has reduced markedly since the beginning of the transition of the R&D system. This is due to the transformation of former ministerial research institutes, which were dedicated to applied research, into privatised so called high-tech companies that are rather seeking R&D services themselves. In addition, FhG reports that universities (and research institutes) in China are free to commercialise their R&D results themselves and have consequently often little interest in providing R&D services to firms.

4.2 VTT TECHNICAL RESEARCH CENTER OF FINLAND

VTT describes itself as the "biggest contract research organisation in Northern Europe". In 2006 it has a turnover of 217 million € and a staff of about 2,800 people working in seven knowledge clusters and 46 knowledge centres. Basic government funding is about 35% (VTT 2007).

VTT opened its representative office in Shanghai in September 2005. Due to this, the office is still in its initial phase. Currently, only one person is representing VTT in China. The office has three envisaged missions:

- Development of a network of potential local cooperation partners (research institutes, universities, firms with R&D capabilities), which Finish firms can utilise for R&D services;

- (Technical) Support for Finish/ European firms, especially SMEs, that are located in China. This includes also general advice on China, research of suitable Chinese cooperation partners (see above) and participation in joint R&D projects between Chinese and Finish firms as a trustworthy partner. Hence, VTT sees its main mission in being an interface between Finish firms (either in Finland or in China) and the Chinese S&T system (including private firms).

- Commercialisation and transfer of know-how and technology to Chinese firms. Even though this is not supposed to become the main business, VTT actively acquires new customers. Most

> Chinese firms look for ready-to-use technologies, some want to improve existing Finish technology in whose development VTT took part. The China office will act as a bridge between the Finish headquarter and the Chinese customer.

The motivation for the establishment of the China office has been encouraged by the Finnish government to provide support to Finnish SMEs in China. The interviewee does not see domestic competition for the kind of R&D service VTT offers. Local universities are rather seen as cooperation partners than as competitors.

4.3 IMEC

IMEC is a public-owned research institute from Leuven/ Belgium. It employs about 1,400 people and has an annual budget of about 240 million € (2005). About 18% of the budget is basic funding provided by the Flemish community while the remaining 82% are mainly generated through industry projects and partly through EC projects. IMEC is specialised in microelectronic, nanotechnology and technologies for ICT systems (IMEC 2007).

In China IMEC focuses on microelectronic in the semiconductors industry. IMEC opened its China office in 2002, because it anticipated a large part of the semiconductor industry to move facilities to China. Currently, two persons work in the office. IMEC's aim in respect to the Chinese market is to offer joint R&D services, licensing and training. Customers are Chinese-owned and China headquartered (listed) companies. Background for IMEC's "very successful" (interviewee) work in China is the very expensive infrastructure for research in microelectronics. Chinese firms can either not afford or are reluctant to invest in this infrastructure. In addition, ready to use technology which can be procured from multinational companies has a high market price. Hence, it is frequently more attractive for those firms to collaborate with IMEC in order to acquire, understand and develop (own) technologies. IMEC either provides the opportunity for joint R&D or technology transfer and related training in Belgium. Despite its self-perceived success the interviewee states that the number of potential customers in China is fairly limited and most customers require older technologies. In total IMEC has recorded one joint R&D project and four contracts that include a combination of technology transfer and training since 2002.

4.4 HELMHOLTZ ASSOCIATION OF GERMAN RESEARCH CENTRES

Helmholtz is an example for a different segment of the research sector. Helmholtz is the umbrella organisation of 15 scientific-technical and biological-medical research centres in Germany employing some 24,000 people. While most of the individual research centres are around for several decades, Helmholtz itself was founded as recently as 2001. About 70% of the member institutes' budget is provided by the state while the remaining 30% are covered by revenue from research contracts. Hence, Helmholtz institutes are rather oriented towards basic, large scale research (Helmholtz 2007).

Helmholtz opened the representative office in Beijing in 2004, it is run by two persons. The main objectives of the office are to establish and promote the brand name 'Helmholtz' in China, to organise Chinese-German workshops, to assist delegations from member institutes, to support members in identifying suitable cooperation partners and carrying out joint research projects (bridging cultural differ-

ences), and to act as an access point for Chinese students who whish to apply for a position in a Helmholtz member.

Presently, Helmholtz activities with Chinese partners (especially CAS institutes) are oriented towards basic research, but the interviewee sees for the future the opportunity for technology transfer and joint technology development with Chinese research institutes or firms as well as for the commercialisation of some technologies. For example, a high performance membrane from GKSS has found several applications in China for its "energy saving and environment friendly" character. Moreover, the huge energy demand in China creates an attractive market potential for the BTL-biomass project (e.g. synthetic bio-diesel) from the Forschungszentrum Karlsruhe. A cooperation project for joint research and demonstration has already been signed and is going to be implemented in Shandong Province.

4.5 TNO

TNO is one of the largest RTOs in Europe being the major organisation of applied research in the Netherlands. After an extraordinary reorganisation during the last years the organisation is now built up by five core areas of competence with about 4.000 employees and a turnover of about 500 million Euros in 2006. Government funding is given by 196 million Euros in 2006 (TNO 2007). In its new strategy plan 2007-2010, internationalisation has a prominent role adapting an 'open innovation' model. While there are first steps made by founding offices in Brussels, Toronto and Yokohama mainly for marketing and sales, the Chinese market is approached via offices belonging to subsidiaries of TNO and some joint ventures.

TNO Companies BV, a holding company for all the privately owned TNO subsidiaries was setup to commercialise and exploit knowledge developed by TNO. This organisation incorporates in its portfolio TASS ("TNO Automotive Safety Solutions"), a company which was founded to commercialise and utilize software (madymo) for simulation of design and crashes developed at TNO Automotive. Consequently a worldwide network of regional offices is implemented including offices in China (Beijing and Shanghai).

In December 2006 a joint venture, the Beijing Building Technology Development Company Ltd., was signed, involving TNO Companies BV, the Beijing Construction Engineering Group Company Ltd. (one of the largest national construction companies) and its subsidiary, the Beijing Building Construction Research Institute. The mission of the Joint Venture is to carry out building and construction activities for Beijing and and Europe. TNO Companies BV holds 49 per cent. Moreover, it contributes capital, know-how on topics such as sustainability and energy reduction, and management expertise. TNO expects "… a foothold in China through an organisation that is well embedded in the local community; this enables TNO to also lay contacts with other, non-Chinese organisations active there." (van der Klauw 2007). Moreover, TNO hopes to be involved in Chinese projects at an early stage and hence to influence the specification of the required equipment, thereby creating demand for European technology. An additional motive is access to Chinese knowledge.

5 Summary and conclusion

In this paper we argue that RTOs are a very special albeit inhomogeneous breed due to their multiple functions, organisational forms and their hybrid character, which includes public/academic as well as private/business elements. Since "RTOs originally were creatures of policy" (Hales 2001: 66) that were set up to close a (perceived) gap in the national or regional innovation system and to foster national industry, governments still bear are strong influence on RTOs. This influence is conveyed through funding or governance arrangements. These organisational framework conditions pose a strong impact on (and even obstacle for) RTOs' ambitions to internationalisation. In consequence, only few RTOs seem to have internationalised in a business-like manner by setting up R&D facilities abroad. Rather RTOs seem to follow a 'soft', academic type of internationalisation, carrying out international joint research and attracting foreign (EU) funding.

Using five case studies of European RTOs in China as illustrative examples, we conclude that compared to the (idealised) stage-like internationalisation process of enterprises, RTOs would qualify for the first level of setting up foreign sales offices in order to facilitate the export of R&D services (Figure 1). Thereby, the case study RTOs do not follow existing customers to new markets, but rather try to attract new local clients. Moreover, they show no intention (yet) to carry out R&D work in China. Consequently, the main motivation of RTOs is home base exploiting (Kuemmerle 1999), i.e. cashing in on existing competitive advantages, trying to achieve early mover advantages (such as learning in unknown environment, building up reputation, establishing social networks etc.) in a promising market. These motives are supplemented by some home base augmenting, i.e. screening for new know-how and scientific developments in China as well as recruiting human resources for their institutes in the home country.

Interestingly, some RTOs (FhG, Helmholtz, VTT) were supported or even asked by their respective governments to set up an office in China. Here, the establishment includes a multi-mission approach: Besides attracting contract research the objective is to participate in research collaborations motivated by "development aid" reasoning, support for public research in international collaborations or to support domestic SMEs in their internationalisation efforts. Consequently, in these cases RTOs' position in arms length from government have obviously led to a portfolio of activities that 'justifies' their engagement in China. At the same time there are examples of RTOs who seem to be in China mainly for profit oriented marketing activities (TNO, IMEC) without further activities or explicit government intervention.

Further research is needed to substantiate our (qualitative) claims with quantitative data, to learn more about the real status quo of RTO internationalisation and of different strategies/ approaches to this issue depending on individual RTO characteristics.

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