RISE - RTOs in the service economy

Final report

Synthesis report, workpackage 6

Birds were dinosaurs once - The diversity and evolution of research and technology organisations

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A final report of RISE: RTOs in the service economy - Knowledge infrastructures, innovation intermediaries and institutional change

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This report constitutes a deliverable specified in the RISE work programme

Contract number: SOE1-CT98-1115

Funded under the TSER programme by the European Commission, DG Research

Date: January 2001

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A separate summary of this report is available

This report, its appendices and the summary may be downloaded from: http://centrim.bus.brighton.ac.uk/go/rise/

Abstract

The RISE agenda has three components:

- Mapping the changing shape of innovation systems in the service economy, and addressing the diversity of national and sectoral arrangements.
- Examining and evaluating the working balance between contributions (including funding) of public and private sector actors in innovation systems.
- Developing strategies for generating and presenting knowledge on innovation systems, as a contribution to the strategic steering of courses of action by actors who wish to change the trajectories of innovation systems.

Semi-public research and technology organisations - so-called RTOs - have been taken as the tactical focus for this exploration of mapping issues for policy purposes. No general description covers all RTOs but a stereotypical definition serves as a basis for discussing the term's many variants and interpretations: *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*. RISE research has generated ten principles that should inform government policy related to RTOs. Under the above three headings, these are:

Mapping

1 Adopt a perspective of a hybrid public/private economy of research and technology services (R&T services). RTOs form merely a part of a broad 'manifold' of tacit and explicit services covering both innovation and operational needs of firms relating to technology and systematic, research based knowledge.

2 Adopt a service economy perspective, rather than a one based on R&D for manufacturing. Service innovations are very significant in all sectors. Government services can be parts of the productive knowledge based economy.

3 Identify the actual innovation functions of RTOs and other actors in the innovation system. Institutional labels are not reliable indicators of service content, or guides to international comparison. Research is needed (mapping) to support policy action.

Distribution of funding

4 Innovation is not the only function of public-funded scientific and technical institutes. Safeguard multiple roles of RTOs under other aspects of policy (for example, social exclusion, literacy, the democratic process, social capital).

5 Assess the contributions of R&T services suppliers (eg public-funded RTOs) in specific clusters, rather than treating them primarily as an aggregated supply sector in the ('new') knowledge economy. Even though framework measures (eg tax rules for R&D, legal regimes for intellectual property, etc) may apply to some broad functions of 'knowledge transfer' services organisations, these organisations do not necessarily constitute a coherent sector and their contributions to innovation dynamics are a function of cluster context.

6 Facilitate and fund collaborative R&D in supply chains.

Steering and encouraging trajectories

7 Build firms' competences to use external research and technology services. In most advanced countries, articulating demand is more important than increasing the supply.

8. Through collaborations with cluster actors, informed by empirical research on innovation dynamics in the cluster, match services to actors' requirements in strategically important clusters ('high tech' as well as 'low tech', new as well as traditional industries).
9. Facilitate a sound division of labour in the R&T services economy, between the different kinds of kinds of suppliers and service contents identified by the RISE mapping schema for an economy of innovation services. Use a full, integrated repertoire of government roles, including the supply chain roles - powerful purchaser and developer/franchiser of new services - as well as funder, regulator and standards agency.
10. Facilitate changes in the service modes of RTOs. Reward systems, intellectual property norms, etc may need to be changed.

The range of issues above have been addressed in a compact policy briefing document for a fictitious Minister of Innovation. This brief also emphasises a distinction between classic market failure and 'market failure of the second kind' (institutional failure or system failure) as rationales that may jointly underpin policy.

The 'hybrid economy' principle (item 1 in the above ten-point list) has been embodied in a new mapping schema proposed for innovations systems. The schema addresses an innovation system as a hybrid economy of tacit and explicit innovation services. It is function-based rather than institution-based. We regard this as an important principle in the analysis of innovation systems for policy purposes (item 3 above).

RISE adopted a strong focus on the cluster level as the appropriate level of analysis for innovation systems - in contrast with country or sector. This orientation has become strengthened as a result of our research, and cluster-level focusing provides a core theme in our ten principles for policy analysis and research.

In the context of a service economy, RISE proposes that government funding programmes for innovation may themselves be considered as specialist financial products at the core, with tangible or intangible scientific and technological deliverables added in to complete the service package. In this respect, the traditional services of RTOs (delivered to firms under government core or programme funding) can be seen as customised versions of generic government service products. A two-layer model of policy practice seems to fit this relationship, as indicated by the maxim: *Innovation policy is not completed until it has become an innovation service; and services are not completed until they are received ('seized') by specific firms as competences, in the operational-competitive context of their cluster.* Within the RISE analytical framework the 'service layer' of policy practice - as distinct from a generic, 'framework layer' - can be interpreted as cluster-focused programme activities.

The RISE final report and summary, workpackage synthesis reports, country reports, cluster studies and theme papers can be downloaded from: http://centrim.bus.brighton.ac.uk/go/rise/

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Chapter 1 Introduction - RTOs, actual and stereotypical, diverse and evolving

RTOs - research and technology organisations - have been created in most industrialised countries, as a vehicle of industry policy or RTD policy and partly funded by public funding - to serve the innovation needs of firms and to facilitate the transfer of knowledge from the science base. There is sometimes a conventional view that RTOs are dinosaurs, over-large, slow-moving, institutions with brains in their tails, created by the public sector, fated for extinction as their niche disappears in an increasingly dynamic and competitive context of traded services. In many countries the structure of the RTO system might appear to be a case of 'industrial archaeology', shaped at a time before the significance and predominance of the service economy was acknowledged and when manufacturing industries stood centre-stage in the innovation perspective. In some cases the origin of RTOs as public-funded organisations has continued to be visible in a poor 'downstream' orientation towards service to their supposed client base - firms - compared with their strong 'upstream' orientation towards scientific work and the output of scientific results. The focus of RTOs remains generally on physical technology and client sectors in manufacturing industries, as distinct from knowledge-based activities of a broader kind within an emerging knowledge-driven economy, a broader range of activities in support of innovation (less centred on physical technology) and the support of innovation in other sectors.

These are stereotypes. All of these stereotypes are falsified by some RTOs in some countries. In some countries RTOs are amalgamating or forming alliances in order to deliver new, more entrepreneurial ranges of service that fall outside the traditional span of RTOs' scientific activity, or to deliver services on an integrated basis that constitutes a new order of service provision. In other cases the continued existence over decades of an institution with the same name, perhaps operating on a scale of thousands of staff, hides a dynamic internal system of discrete operating units through which new technologies and new services are promoted under the brand image represented by the old-established name. Many RTOs in the past decade have sought and adopted best-practice measures of performance and internal management as customer-service organisations, exchanging between themselves in various professional associations (eg WAITRO at the global level, or AIRTO in the UK) the emerging knowledge of this specialised form of management in innovation services and an increasing sense of operating as a competitive sector in a dynamic, globalising economy. Even though ownership of significant knowledge assets on a large scale is not very common, RTOs increasingly play a complementary role within the commercialisation of knowledge - for example, in performing 'due diligence' studies to support the decision process in venture capital operations.

The RISE project - *RTOs in the Service Economy* - is concerned with these stereotypes and the actual dynamism of those parts of the service economy that offer innovation services to other organisations as clients, notably to firms. We began this study in the belief that innovation services are an increasingly important part of an innovation system, but also widely misrepresented, under-recognised and intrinsically difficult to map because of their diversity, dynamism and emergent nature. If these economic activities - whether provided by public, semi-public, private non-profit or fully commercial organisations - are to be taken into account by governments as they attempt to improve the conditions of innovation and competitiveness in their national firms, they need to be mapped. Particularly, we believed, the *functions* furnished by these services need to be mapped, as distinct from simply making an identification of service-

suppliers at the institutional level using out-dated or imprecise terminology - such as the old term 'RTO' and the more recent term KIBS (knowledge intensive business services firm). With an adequate function-based mapping it ought to be possible to identify weaknesses in structure and content of an economy of services, and promote structural and institutional changes that result in an appropriate range of support to firms innovating in differing industrial and competitive settings.

It turns out that this function-based mapping approach is less straightforward than we thought. A relatively simple model of innovation functions, which we adopted in the survey workpackage of RISE, proves unable to resolve sharply the kinds of difference between diverse types of RTOs, and between RTOs and KIBS firms, that we observe to exist in practice. Clearly, some more elaborated model of the content of RTOs' services is called for, if RTOs and KIBS firms are to be distinguished on the basis of their service content. Also, it has become clear from our research that the differences between different types of RTOs and between RTOs and KIBS firms are in fact, to a substantial degree, differences of institutional form rather than the functional content of their service outputs. In other words, RTOs and KIBS firms may sometimes perform functions for their client firms which at a certain level of analysis seem to be similar (for example, services supporting product development, testing or certification services, or prototyping services), but they provide them under different institutional terms of reference which perhaps lead, for example, to different price conditions in markets with different dynamics. Particularly, RTOs of the classical kind provide services under some degree of public funding and often to collectives of firms as a 'constituency' rather than to individual firms on a contract basis. It is a matter of interpretation whether such differences of institutional form, 'governance' and service delivery constitute different service contents or simply differences in the delivery of the same (functional) content. In other words, the notions of 'function' and 'service content' themselves require further consideration; and both are perhaps more bound up with institutional form than we initially thought. More of this later.

The term RTO embraces organisations funded through a variety of mechanisms including membership subscriptions from firms, fee-for-service activities (for individual firms or government clients) won as competitive contracts, government core funding, and competitive contracts for public grant-funded R&D projects. Organisations described as RTOs typically have received between 20% and 100% of their funding in the form of government base funding and carry out activities including some mix of:

- Bridging between the science base (eg basic research in universities, sometimes in the RTOs themselves) and national firms to facilitate manufacturing product or process innovation and the dissemination and uptake of new technologies.
- Applied and applied strategic R&D oriented towards specific industrial sectors or technologies that warrant government attention, under policy programmes, collectively commissioned by firms in the RTO's constituency, or under other modes of direction.
- Development or dissemination of scientific and engineering standards and information, as a public-service infrastructure for national scientific and engineering activity.
- Best-practice initiatives in the management of technology by national firms to improve their competitiveness in global markets, including training, consultancy and information publishing.

All industrial countries have some institutions equivalent to RTOs. In Germany, the Fraunhofer institutes are well-known, as is TNO in the Netherlands, VTT in Finland and SINTEF in Norway;

all these are strongly oriented towards industrial applications. Sweden has relatively few RTOs of this kind and bridging functions are typically performed there by universities. Less-developed EU and Mediterranean countries and countries in the ex-Soviet Union typically have large state-operated applied R&D laboratories in which the bridging function with industry is less well developed but the science base can be strong in specific areas (for example, biotechnology in Portugal). Ex-colonial countries such as South Africa, Trinidad or Australia may have a 'Council for Scientific and Industrial Research' which operates as a national RTO. Countries with strong regional politics - eg India, Norway, Germany, Japan - may have complex layered systems of national, regional, local and industry-specialised RTOs and educational institutions.

RTOs have been established differently and have evolved differently in the context of different national systems of innovation. Within a single country's policy framework individual RTOs may adopt different strategies depending on their technological and industrial context, so that institutions with the same name and formal institutional designation may in fact display quite different mixes of activities and styles of operation within the formal constraints of their institutional conditions (eg funding rules or charters). Or at least, operating units within an RTO may have quite different styles of operation and strategies for service provision and funding. In some cases there is uniform policy within a country towards RTO funding and activities and in others RTOs have been liberalised or privatised, in which case the diversity becomes even greater as organisations of different size, resources and positioning seek to develop operating strategies that will make them viable in various national and transnational sector and technology markets.

Individual RTOs respond more or less dramatically and effectively to a combination of three trends, in various strengths and combinations:

- Innovation modes have shifted in terms of the outcomes of innovation (eg physical products compared with services) and the forms of social organisation involved (eg networks, collaborations, formal internal processes of R&D);
- Markets for innovation-related services have developed - for example, the outsourcing of R&D and design, benchmarking of products and practices, strategy consulting, implementation of new-technology systems; and
- Policies regarding government-funded services and functions have shifted, favouring market forms and reduced public spending. Reductions in government funding for R&D and innovation are ongoing, as part of a systematic restructuring of national systems of innovation which includes rebalancing between public- and private-funded activities.

Consequently, RTOs show great diversity. Their functions have changed and continue to change, along with the rationales used by governments to justify or deny funding or other special financial measures ('market failure' measures) such as tax status. This diversity reflects, among other things the diversity of national systems of innovation (NIS) and especially the differing agendas of political institutions. For example 'support for R&D' at the firm level, as an allowable form of government spending, is interpreted more liberally in the Scandinavian countries in line with a social-democratic ethos, and less liberally in its application to ex-East Germany where it soon becomes interpreted as unfair competition.

Because the institutional form and mix of operational functions shows great variety, the term 'RTO' is better understood as expressing an ideal type rather than providing a meaningful description of all (or even any) of the many different kinds of organisations to which it is applied. It seems impractical to maintain either a single canonical definition of 'RTO' or a generic template for policy towards actual RTOs in actual systems of innovation. In this report we therefore adopt two devices:

- First, a stereotypical definition of RTOs which serves as a basis for discussing the term's many variants and interpretations: *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*.
- Second, in contexts where it is necessary to stress the actual diversity of RTOs we will refer to organisations in different industries or different countries, which are referred to in that local context as RTOs, by using the term RTO*, signifying a 'so-called RTO' which departs in some significant way from the stereotypical or 'classical' RTO form.

So-called RTOs (RTO*s) can depart from the stereotype to the extent that - as in the case of ex-cooperative research associations in the UK - they receive no public core funding at all and operate without any charter or other government involvement in their activities. In terms of operational realities such as generating revenue such RTO*s are in fact KIBS firms, except that (again in the UK case) they do not distribute profits and, being operated under some kind of trust arrangement, retain to a greater or lesser degree a residual 'public' form and orientation. Rather than being 'semi-public' they have become 'private non-profit', and as such the relation between their activities and the provisions of national innovation policy requires different consideration.

Rather than operate simply with a stereotype of RTOs, we need to be aware of a system of typical assumptions or tacit conditions covering three inter-related 'sectors': RTOs, KIBS firms and policy practice linked with RTOs. Exploration of these assumptions and conditions constitutes the scope of the present research project. These assumptions and conditions are outlined in Box 1.

Box 1 Typical assumptions and conditions related to RTOs, KIBS firms and policy

RTOS...

are public-funded organisations (as some significant proportion of their revenue)

RTOs have public roles (which justify public funding) in the following areas: correcting for market failure in the diffusion of technology and conduct of R&D (for example, performing R&D for collectives of firms); contributions to published scientific research; contributions to the pool of qualified scientists and engineers

The mix of roles and revenues of RTOs is changing (giving rise to challenges in RTO management)

Public funding for RTOs is falling and pressures to increase other sources of funding are strong

KIBS FIRMS...

are fully commercial and financially independent of government (in contrast with RTOs).

KIBS firms are not expected to have any public function. Private non-profit organisations - operating on a fully commercial profit and loss basis but not distributing surpluses to shareholders - have an ambivalent status because of the 'public' elements in their governance. Some PNPs - eg in the UK - are more like KIBS than others (eg in Germany) as regards financial independence.

As organisations in the service sector, KIBS firms provide explicit services ie intermediate services (producer services, knowledge intensive business services) to firms

Services are delivered in one-to-one relationships between a service supplier and a client firm (but often the client and sometimes the supplier is a large organisation with a complex internal structure of business units)

Markets for KIBS are growing. Service activities such as R&D are increasingly being outsourced as firms focus on their core business, the technological scope of their activity extends beyond their traditional competences, and KIBS firms develop specialisation's that cannot economically be handled in-house

POLICY...

views RTOs primarily as bridging between the science base and industrial practice, and sees this as a priority that is secondary to the promotion and funding of activity in the science base (with exceptions in some policy areas such as defence where the government as procurer has a strong interest in the quality of technology transfer)

As an aspect of the reduction of the State (or at least, of public spending) and the expansion of the market, government funding for R&D, RTD and innovation will continue to be reduced and cheaper forms of policy will continue to be sought.

Rather than providing core funding to institutions such as RTOs, it is increasingly preferred to fund them via programmes. This gives more 'steering' power over the outcomes and direction of their activity, and yields easier measurements of efficiency in the spend of public funds

Government activities are increasingly conducted through hybrid forms of organisation that are either public-private collaborations or contain organisations with an ambivalent status (arms-length agencies and branded franchises, private non-profit trusts, chartered organisations, etc). This includes many aspect of formulating and delivering innovation policy.

Despite their increasing (enforced) independence RTOs are often expected to 'belong' to government bodies on a territorial-geographical basis. 'The man who pays the piper calls the tune": and so we - as funders - expect 'our' RTOs (our universities, etc) to service 'our' industry. This occurs at national level (eg RTOs may experience tensions with their national government when they service foreign firms from the national science base). But it occurs more especially at the regional level, where direct links in a local economy - typically, local universities and firms, sometimes regional industry-specialised RTOs - are often privileged over remote linkages in a global economy and global science base. This may make it more difficult for an RTO to attract government funding to establish itself in a global-niche role rather than a local-generalist services role.

Different funding mechanisms have different bearing on the scope of control available to the funder. Core funding, programme funding and fee-for-service are all forms of relationship that may exist between government bodies and RTOs. The mix of mechanisms existing for a given RTO will have a substantial effect on the degree of 'ownership' and steering over RTO strategy and services that can be asserted by government.

Issues associated with these typical assumptions and conditions will be explored in discussing the RISE findings, in the three remaining main sections of this report, as follows:

Chapter 2 RTOs in national systems of innovation

This chapter discusses: the involvement of government with RTOs; roles of RTOs in relation to other actors in national systems of innovation (NIS); and differences between the RISE countries (Norway, Sweden, Germany, the Netherlands, the UK and Portugal).

Chapter 3 The strategic contribution of RTOs

This chapter discusses: the roles of RTOs in innovation clusters; issues associated with the shifting relationship between services supplied by RTOs and KIBS firms ('KIBSification'?); and the delivery of innovation services into firms and the outcomes of these interactions.

Chapter 4 Innovation policy and RTOs

This chapter discusses: 'institutions', institutional change and policy learning; the kind of brief that a Minister might be given consistent with the RISE approach; ways in which our research has changed our interpretation of three core questions concerning mapping, funding and steering in innovation systems; and ten key principles for policy related to RTOs.

Chapter 2 RTOs in national systems of innovation

The RISE study adopts a perspective within the broad spectrum of 'innovation systems' approaches. In this chapter we locate the objects of our research, RTOs, within an innovation systems context. The chapter has three sections:

- RTOs, government and governance
- RTOs and other suppliers of innovation services in systems of innovation
- RTOs in different countries

2.1 RTOs, government and governance

RTOs are connected with government in several ways. Each of these has implications for the autonomy of an RTO as an actor in a system of innovation and sometimes for the spectrum of services that it can supply, the terms under which they may be available to firms, or the markets that it can operate in. Four relationships between RTOs and government should be considered:

- Public funding
- Steering or regulation of activities
- Participating in a regulated, liberalised or promoted market
- Government as a customer for a hybrid mix of services

These are explored in Appendix 1: *RTOs, government and governance*.

The stereotypical RTO - receiving core government funding (or even, being wholly government owned and largely government funded) - is diminishing in its incidence, compared with forms of RTO activity where government is involved in a more 'tactical' or functionally specialised way. Particularly, steering at programme level is increasingly replacing elements of core funding for RTOs. The steering power of government as a franchise-holder for an RTO's services (eg measurement standards, safety standards) can be considerable if this activity generates a substantial part of the RTO's revenue; equally the power of government can be significant within supply chains, as a dominant, core consumer of certain services from an RTO (eg services related to defence such as R&D or systems evaluation; public-analyst services; etc).

The extent to which RTOs participate in markets, and their modes of participation, is determined strongly by government. At one level, governments committed to the expansion of the market and the reduction of the State will adopt an approach to RTOs which places all or some of their services in the market and outside public funding. Various mechanisms are available for this: 'agency' status for public bodies, 'market testing' of government services against private services, liberalisation, privatisation. Certain policy actions oriented to the expansion and fluent operation of markets bear strongly on the service trajectories of RTOs and cognate organisations in the public sector. Promoting the commercial exchange of intellectual property is an such area where organisations receiving public funding for R&D may be encouraged or required to increasingly package outputs in the form of intellectual property assets for the market sector. Even in the UK, where the commercialisation of RTOs has gone furthest, the process of expanding the market

activities of agencies whose primarily mission is the generation of 'public good' science is still ongoing, via the liberalisation of property regimes in public sector research establishments.

Governments may identify market failures and system failures associated with the production, consumption and distribution of scientific and technological knowledges and competences. Typically, for example, SMEs are seen as disadvantaged in their capabilities for identifying and exploiting external sources of knowledge and competence for purposes of increased competitiveness, while being under-resourced internally and carrying large amounts of risk within globalising supply chains. On this basis many extension services and consultancy services are promoted. In some cases, rather than being seen as permanent faults in a market requiring a standing contribution from public-funded services, problems of this kind may be diagnosed as transitional failures which eventually may be resolved by the creation of new markets for services. Public funding may then be tapered over a period, in the expectation that the subsidised delivery of services will educate target user population to the point where demand will sustain a conventional market.

The majority of RTOs must be seen as hybrid because they do not only provide innovation services (to firms) but also other services (especially services to government) which are not innovation services. For example, RTOs may provide expert opinions in legal processes or processes of legislation. They may provide contributions to public debate and the democratic process. They may provide public goods in the form of published research results and other outputs which are more easily reckoned as 'cultural' or even 'political' production (specialist or generalist literacy within the national population, formation of social capital in areas of major theoretical development, etc) than as contributions to an innovation system and incipient contributions to 'the production system' of industries. In these areas government may be the client, or just the customer. Such services sometimes may not be marketable, and thus need to be incentivised, rewarded and evaluated in ways which differ from the reward systems appropriate for tradable services.

When evaluating any actual RTO from a policy standpoint is it vital to consider the full range of functions in which it is involved with government. The RISE study is concerned only with the aspects of RTO activity that can be regarded as innovation services to firms.

A full analysis of the governance issues associated with RTOs falls outside the scope of the project. Further research in the area opened up by RISE should take steps to thoroughly characterise and study these issues further at four levels:

- *Institutional governance*: the governance of an RTO as a discrete organisation. This involves analysis of its assets, formal management arrangements, performance evaluation criteria and mechanisms, funding mix, strategic positioning, operational autonomy, client base, etc and the ways in which these bear on the economic form and operational content of the services offered by the RTO and position them in relation to services from other kinds of suppliers.
- *Interaction governance*: the governance of service-level interactions with clients. This involves identifying various types of service packages and studying their delivery and absorption into client firms, paying attention to the scale and scope of these interactions and the material form of the interaction (its 'presentation mix'). These should be related to the forms of contract and other relationships (eg preferred-supplier networks, alliances, etc) employed to contain and organise different kinds of service 'performance'

and to mobilise, deliver, generate and protect assets within the 'interaction space' of a service delivery; and

- *Governance in the post-modern State*: the governance of distributed networks of policy-development and public-service delivery activities and the operational management of policy programmes and policy agencies as systems of services delivered by multiple agents to government and to the clients of government.
- *Supply chain governance*: the distribution of power and strategic autonomy within supply chains, according to the location of a firm (head of chain, OEM/systems integrator, second- or lower-tier supplier, global niche specialist, etc). This affects business strategies and innovation strategies, and hence, the drivers for competitive advantage in that supply-chain location and the innovation services that may appropriately be anticipated.

The last two of these fall outside our range in RISE. The first two are considered in our analysis, as determinants of the product range and product content of RTOs.

For a more detailed discussion of RTO relationships with government see Appendix 1: *RTOs, government and governance*.

2.2 RTOs as suppliers in a hybrid economy of tacit and explicit innovation services

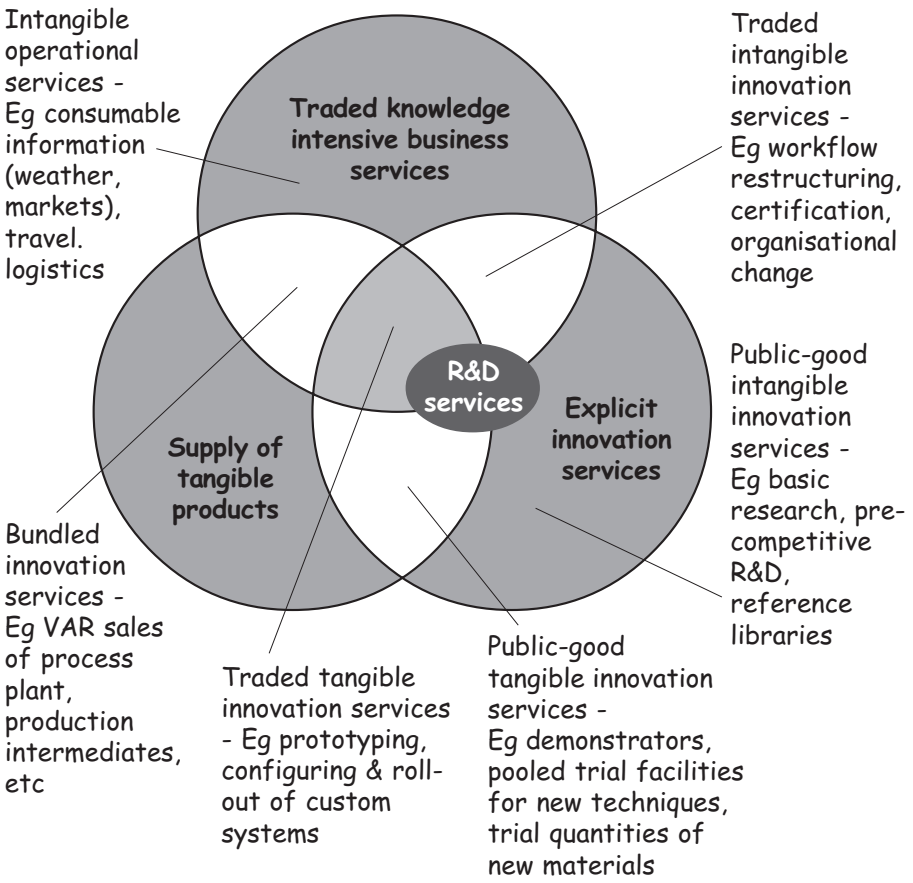
RISE interprets an innovation system as a system of tacit and explicit innovation services. We have become increasingly aware of RTOs as suppliers of explicit innovation services, in a context that also contains 'self-service' elements of supply and the supply of tacit innovation services that are 'bundled' with non-service products or non-innovation services (ie operational services).

Figure 1 is included to show that in the context of technology-related services, several categories overlap (as do their complements, in brackets):

- Traded business services (non-traded 'public' services)
- Supply of tangible products (supply of intangibles)
- Explicit innovation services (tacit innovation services)

RTOs may be involved in any or all of these categories of activity, depending on the rules under which they operate. In some of these areas they normally must expect competition from non-RTOs. In terms of this function map, the stereotypical RTOs segment comprises non-traded (public good) explicit innovation services (including R&D) generating either tangible outputs (such as prototypes or specialised materials) or intangible ones (such as learning or information). The trajectories of RTOs as service organisations may be mapped partly by their moves into the other segments of service provision. Trajectories of RTOs are discussed in Appendix 7 of this report.

Figure 1 **Categories of technology- and knowledge-related services**
(R&T services: research and technology services)



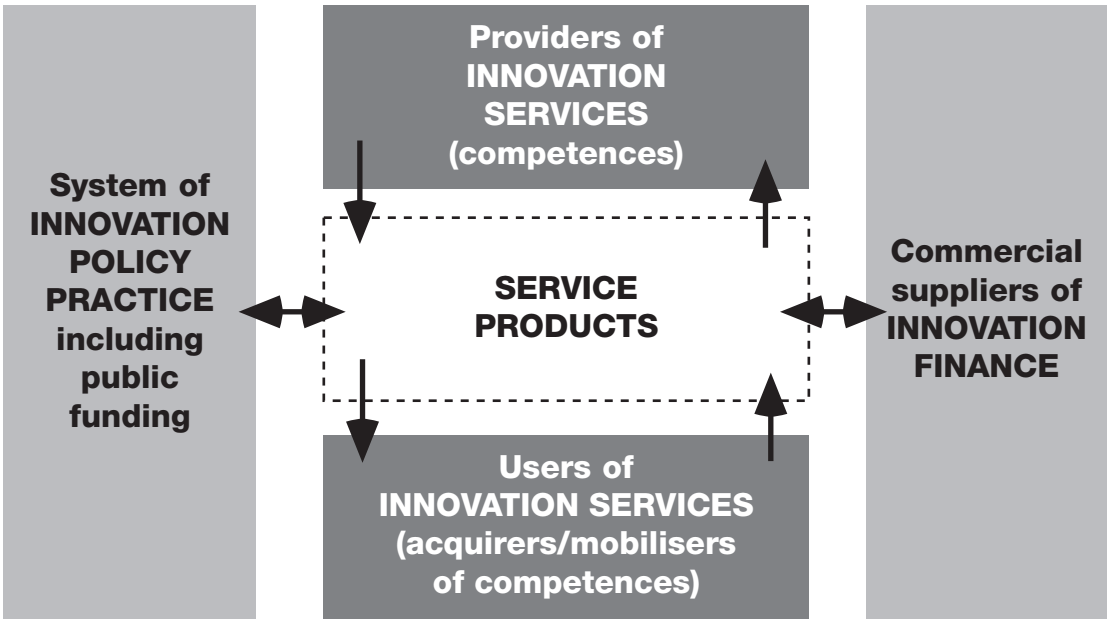
In chapter 1 we referred to the 'function' orientation of RISE. One implication of a function-based approach to the mapping of institutions in an innovation system is that differences between different conventional classes of institutional actors cannot be taken for granted. The functions performed by RTO*s cannot be assumed to differ significantly from at least some of those performed by KIBS firms on one hand, or from those of university institutes on another. Thus the specificity and distinctiveness of what RTO*s do becomes something to empirically establish in the context of a particular historical system of innovation, rather than something that can be read off from the fact that they are (called) RTO*s. This brings challenges in terms of sampling (what is a relevant sample population within which to explore the distinctiveness of RTOs?) and data gathering (what kinds of categories can be assumed to stretch across the various classes of actors being addressed by a particular mapping instrument?). These issues are discussed in the final report of the RISE survey workpackage (Preissl, 2000b).

Another position taken by RISE was that 'cluster' rather than 'sector' was a necessary perspective for the analysis of innovation services and relations between service suppliers and client firms. On one hand this implies a multi-sectoral approach on which different kinds of institutional actors will be treated together as elements of a cluster. On the other hand it implies that the characteristics of RTOs as a 'sector' (this implies homogeneous outputs, something that is easily challenged for RTO*s) are of secondary importance compared with the roles that actual RTOs perform in actual cluster-systems. Cluster is in fact the primary 'sampling' principle in RISE for studying RTOs, mapping their contributions to systems of innovation and comparing their roles

with those of other actors. The RISE approach to clusters is discussed in the final report of the RISE cluster workpackage (Whalley & den Hertog, 2000). In chapter 3 we will identify some of the key roles of RTOs in cluster-systems of innovation. In the present section and Appendix 2 we identify some of the other classes of actors whose activities need to be taken into account from the point of view of a function-based analysis of innovation services and their contributions to innovation.

We have generated a general mapping schema for a function-based map of an innovation system, shown in Figure 2. On the basis of our cluster studies and case studies this template can be given more detail, resulting in the map of a *cluster system of innovation* shown in Figure 3. For the derivation and rationale of this map, see Appendix 2 to the present report.

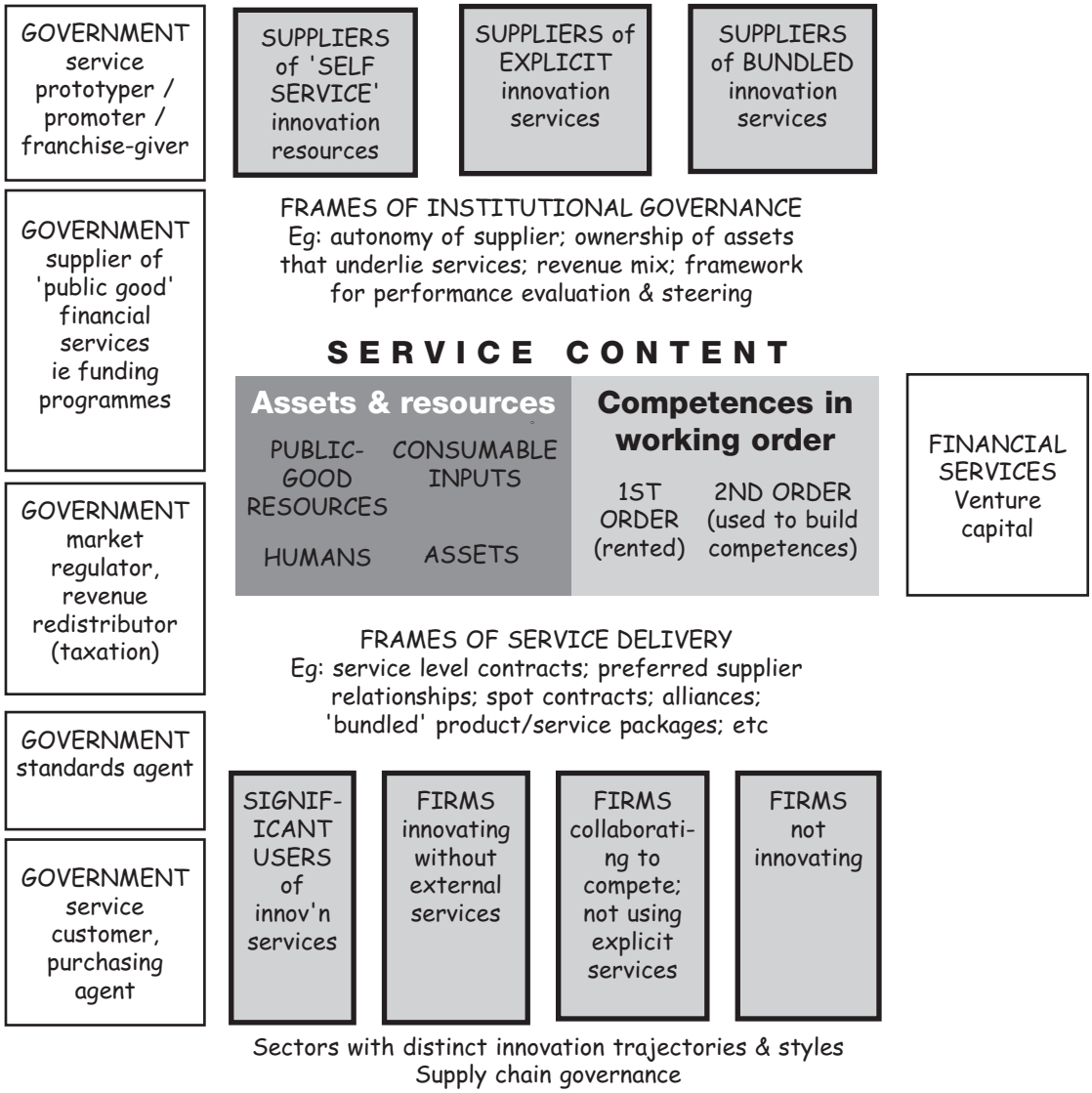
Figure 2 **An innovation system as a system of tacit and explicit services**



The mapping of Figure 3 recognises that RTOs and other suppliers of explicit services are not the centre of the universe as far as innovation is concerned. This is why a 'hybrid' rather than a pure map is called for. The map entertains the possibility, and supports the mapping, of innovation occurring between firms within supply chains (for example, capital goods suppliers or VARs promoting process or product innovation in user firms via applications-oriented services bundled with their equipment or systems), or by acquisition of knowledge direct from the science base (eg by scanning the current research literature as a 'self service' activity), or by mobilising a well-developed competence rented-out by a service organisation (eg a design or project management company). The map also entertains the possibility that a firm may mobilise and appropriate (temporarily, within a service or supply contract) a competence of an external, innovative firm without learning or innovating itself; some of the interactions that are mappable with this schema involve technology-related operational competences rather than innovation competences. For further discussion of these requirements of the mapping scheme, see Appendix 2, Sections 2.1 - 2.6.

The mapping of service content at the centre of Figure 3 derives from the 'micro-institutional' mapping framework for competence supply, in RISE workpackage 5: see below, Section 3.3e and Hales (2001).

Figure 3 **Function-based map of an innovation system as a system of tacit and explicit services**



As institutional mappings go, this is about as function-based as it gets. The very broad functional categories of Figure 2 seem rather institutional: providers, users, government. But each institutional category is deconstructed by functions in the detailed version, and none of the categories in the final mapping schema identify institutions as such. This makes such a map difficult to construct routinely on the basis of statistical sources. The breaking-down of the integrity of conventional institutions ('hard institutions', formal organisations) into component activities and different 'political' relationships of governance in different contexts and communities (in-context functions and relationships) is not necessarily matched by established, formal, country-level statistics-gathering processes. However, an important feature of the map

follows from this deconstruction of hard institutions. Functions do not map singly and exclusively on to formal organisations or practical activities. Most organisations do more than one thing at once, as do most actions and interactions. Thus, categories that appear in different sectors of Figure 3 can often be applied recursively and simultaneously to the same organisation.

An RTO, for example, may appear as a *supplier of explicit services* (with respect to firms), a *user of innovation services* (with respect to its own strategies), *recipient of government 'financial services'* (with respect to its own funding, or as a programme-channel to firms), or *user of resources* (eg with respect to universities). This would typically be the case, since RTOs are 'bridging institutions' and may also be independent trading organisations. Similarly, a manufacturing firm that innovates its products within the supply chain may appear as a firm *collaborating to compete, not making use of formal services*, and also as a supplier of *bundled innovation services* with respect to its customers. Government is a service supplier, a supplier of finance, a customer, a regulator of interactions, and so on. The production and consumption occurring within the system is multi-facetted.

This recursion is the root of the mapping strategy's flexibility when it comes to roles in innovation and knowledge transfer (producer, user, 'carrier', supplier and similar intermediary roles). A dyadic relationship of (unspecified) service interaction - between service providers and service users - is at the core of this map. This intentionally replaces the conventional but overly rigid and prescriptive three-stage knowledge transfer process: knowledge production, transfer, application. Mapped under the RISE scheme, a knowledge-transfer or competence-production process may have as many or as few 'stages' and iterations, or intermediaries, mediators and contributors as it, in fact, takes. There is no prescription.

Figure 3 represents a 'hybrid economy' in three senses. First, the map contains public and private institutions and publicly and privately funded activities. This supports one of the basic aims of RISE, mapping the relationships between public and private contributions to 'innovation infrastructure', without making prior assumptions about the relevance and content of one or the other. Second, it contains tacit and explicit services. This reflects one of the characteristic aims of RISE, to develop mapping strategies that do not privilege the explicit, abstracted and exchangeable (classic characteristics attributed to scientific knowledge) over the tacit, embodied and 'sticky' (characteristics of informed in-context actions, competence).

And third, the map includes services whose orientation is innovation along with others whose orientation is routine operations. This is consistent with a tension that exists between images of innovation: on one hand, 'creativity' that generates competitive advantage, 'creative destruction' accomplished through radical product and process innovation, etc; on the other hand, the routine nature of innovative activity as a basic qualifying criterion for participation in many markets, the mundane nature of continuous improvement and incremental innovation. This is suggestive of the possibility that we should orient to 'knowledge intensive' production activities *per se* in other organisations (ie both manufacturing and service sector) when mapping the possibilities, for a given firm, of acquiring competences and innovating via interactions with other organisations. Firms learn by collaborating without necessarily paying for services.

For a more detailed discussion see Appendix 2: *RTOs as suppliers in a hybrid economy of tacit and explicit innovation services*.

2.3 RTOs in different countries

Our results show that RTOs in all countries share the following features: a mix of public and commercial funding; and a mix of activities oriented towards academic research (publications, PhD training etc) and other activities (applied R&D) directly delivered as services to innovation in firms. However, the combinations differ substantially between different types of organisations in different countries. Different institutional forms are dominant in different countries.

2.3a Institutional characteristics of RTOs

Substantial differences exist between the structures of innovation systems in the RISE countries, as regards the numbers, forms and roles of RTOs. At one extreme, RTO*s in Portugal are mainly imbricated as part of a public sector research system which in terms of staffing and funding forms part of the civil service, under a strategy of investment in 'upstream' capacity for basic research. They have poor links with firms. Portugese RTO*s in the biotech sector are semi-public, having a high public involvement and a slow movement towards industrial markets. At the other extreme, RTOs in the UK have vanished, in the traditional sense of organisations part-funded by government to perform 'bridging' functions between the science base and firms. Organisations which were RTOs have been privatised and now operate as private non-profit companies (PNPs); their activity profiles differ from those of RTOs in other countries, with a high orientation towards provision of services and low orientation to academic activities. A variety of UK research establishments which do not have strong links with firms remain in the public-funded sector, linked with government departments or research councils. These, together with university institutes, have a high academic and research orientation but their business and service orientation tends to be higher than similar academic-oriented organisations in other countries. Some large RTO-type organisations that are strongly involved with industry remain within the government orbit as 'agencies', rather than having been fully commercialised, because of their links with defence and nuclear power.

In between these national extremes are other distinct variations. In Sweden the functions that in other countries are exercised by RTOs as discrete organisations are largely devolved on to universities. Swedish RTOs have profiles that in some ways are like the UK PnP organisations except that they are semi-public; they have a strong business orientation and a rather low academic and research orientation. Universities in Sweden maintain many of the functions allocated to RTO*s in other countries and the RTO sector is small.

The German system contains a variety of institutions with differing orientations towards the academic science base and industrial firms, within a complex of formal national and federal arrangements for semi-public and wholly public funding. Distinctively, many RTOs are organised in large research societies. This guarantees a relatively high level of institutional and financial stability for RTOs of this type.

Unlike Germany, where there are numerous organisations within any institutional category, in Norway and the Netherlands large 'umbrella' RTOs form significant parts of the public-funded system of R&D. Norwegian RTOs are more closely linked with government than the Dutch. Most Norwegian RTOs are semi-public but receive a relatively low average share of public funding. One very large semi-public organisation dominates the RTO 'sector'. In the food cluster there are considerable differences between 'science' oriented RTOs on one hand (which deal with food

qualities) and technical industrial ones on the other (which deal with manufacturing problems). In the Netherlands, university-based institutes and a few large institutes 'of national importance' dominate the picture. Our survey shows these institutions ranking high on academic orientation and comparatively low on their service orientation and commercial revenues.

The range of varied technologies involved in an innovation process may easily outstrip the capabilities of any single source of technology and competence. In this situation, alliances between RTOs, on either an ad-hoc or an institutionalised basis, are increasingly common. In this respect, the total capability of an apparently fragmentary system such as that in the UK - where there are numerous independent, trading RTO*s - may become comparable in some respects to the capability of a large national core-funded RTO such as the Dutch TNO or an elaborate system of public-funded institutions operating within a formal division of labour - and funding - such as the German Fraunhofer/Max Planck system. The AIRTO 'umbrella' in the UK (*Association of Independent RTOs*) contains individual, privatised RTO*s which are growing in size, and also KIBS firms; a few of the latter possess significant technology assets. This voluntary, trade-based network increasingly functions as a partnering system, through which combinations of competences and assets are assembled to meet contracts. It is described by AIRTO as follows:

> "The annual turnover of [AIRTO] member companies now exceeds £1 billion. Together we employ over 10,000 scientists and engineers. This makes us larger than the Fraunhofer Institutes of Germany and some three times larger than TNO in the Netherlands or VTT in Finland. In fact, we are the largest knowledge transfer community in the EU and, most important of all, we operate without subsidy from the public purse." (AIRTO, 2000: 1)

This illustrates how dynamics and institutional arrangements differ substantially in the different countries, even if the total functional capability of national systems were to be regarded as equivalent.

2.3b Public funding and institutional change

All RTOs experience ongoing decline in their component of public funding (under a variety of policy rationales including budget cuts, tighter control of results from public expenditure via goal-specific programme funding and encouragement to work more closely with industry). Correspondingly, their proportion of commercial funding rises. In our survey of RTOs in Germany and the Netherlands show the most pronounced cut in public funding (between 6-7%, 1995-2002).

The national systems differ with respect to their stability, during the period of research. Although the UK system contains a dynamic market sector with numerous independent RTO*s (actually, ex-RTOs) it is structurally relatively stable. Commercialisation of semi-public RTOs in the UK occurred during the 90s, and while further commercialisation of public-funded labs (eg increasing their output of tradable intellectual property) and the privatisation of the defence RTO remain as ongoing issues, the shape and balance of the system seems unlikely to shift very much as regards government funding flows. According to our survey results in the UK, the institutional stability of private non-profit ex-RTOs is greater than that of semi-public RTOs in other RISE countries; the latter are moving towards greater commercial funding, a situation already reached by the UK organisations. It is in the strategic interests of RTO*s to grow and the average turnover and staffing of UK RTO*s are both increasing. But there is no manifest tendency as yet for mergers or acquisitions between RTO*s (apart from a loss-making UK RTO* acquired by the large Dutch RTO, TNO) as distinct from the disposals that were involved in the UK Government's privatisation of public labs during the 90s (where, for example, the UK National

(sic!) Engineering Laboratory was acquired first by Siemens, then sold to a German science-facilities management company, the Laboratory of the Government Chemist was subject to a management buyout involving public venture capital and the National Physical Laboratory passed into the day-to-day management of a facilities management company, Serco).

The Swedish system currently is going through a major restructuring of funding channels, involving shifts of emphasis between 'upstream' academic and 'downstream' industry-oriented activities. Also there are issues concerning the possible need for more RTO-type organisations in some areas of emerging technology. The German system shows tensions resulting from cuts in public R&D funding of the kind experienced in all countries, but aggravated by a recent drastic rationalisation of the combined RTO structures of the two Germanies and by a review of public funding for RTOs which leaves individual institutes uncertain of future roles and funding levels, even if the overall shape and variety of the system seems likely to endure. In all countries the effects of cuts in public funding are visible in increased commercialisation (actual or projected) of segments of RTO activity and tensions at some level between industrial competitiveness and academic capacity as rationales for public funding.

2.3c Linkage with the science base

RTOs under funding pressures face a problem of expanding their industry related services while maintaining a high level of competence with respect to basic research and the science base. Also, in some fields scientific recognition depends on practical applications of research in industry. The relative weight given to academic/research related activities on one hand and business/service oriented activities on the other is a significant element of the institutional profile of RTOs in different countries. Linkages with the science base and with universities take different forms. A stereotypical RTO performs some academically oriented basic research or applied strategic R&D funded by government, probably via core funding. As government funding declines, especially core or 'institutional' funding, RTOs carry out less of this kind of work. Our survey shows that decreasing public funds resulted in a relative fall in contributions (1995-1999) to the scientific community and to public education in RTOs in all countries (except the UK where there was already a low base at the start of the audit period; policy consulting - another channel for government funding - fell sharply in the UK, 1995-1999).

From a national-systemic perspective greater business orientation of RTOs leads to the question of where, in institutional terms, to allocate public funding for the academically-oriented activity which is required to keep up high levels of scientific and technological competence in RTOs, including awareness of developments. Different national solutions seem to have emerged. The 'German solution' relies on a limitation of market oriented activities of RTOs, as part of their charter and a condition of their public funding. In this situation, market oriented activities developing in RTOs are delegated to spin-offs in the form of KIBS firms. However, synergy is retained through institutional linkages, and through the experience of managing the spin-off itself. A similar situation - focused especially around the generation, exploitation and ownership of intellectual property - exists with Swedish universities and Portugese university institutes, with respect to forming and maintaining relationships with new-technology based firms (NTBFs) in the biotechnology area.

At the other end of the spectrum the 'English solution' involves a sharper division of labour between market-oriented, privatised, ex-RTO PNP companies on one hand and research in public-funded, public-steered and public-chartered institutions on the other. In our survey, UK PNPs rated their non-commercial collaborations with universities less significantly than those

with large manufacturing firms and SMEs. They also rated their commercial collaborations with other PNPs and large manufacturers as more significant than those with universities. Thus it is unclear from our results how effective the link is between these PNPs and the UK science base, compared with other European models in which, on one hand, RTOs are funded to do some research (making them more 'academic' than the UK PNPs) and on the other, are legally required to form formal collaborations with companies for purposes of exploitation or trading. In the UK survey, universities were the only type of organisation (including KIBS firms, PNP companies and government labs) that maintained significant links with activity in the science base and with firms.

For a more detailed discussion of individual countries see Appendix 3: *RTOs in different countries* and the synthesis report for RISE workpackage 2: Preissl (2000b).

Chapter 3 The strategic contribution of RTOs

3.1 Roles of RTOs in innovation clusters

This section draws on the synthesis report for RISE workpackage 1 (Whalley & den Hertog, 2000) together with the cluster studies listed in Appendix 5 to the present report. These should be consulted for further details.

Fundamentally the cluster approach within RISE has the aim of addressing systemic imperfections in innovation systems, supporting the derivation of policy recommendations and facilitating strategic policy collaborations and actions. It is not merely an analytical framing, but also a way of pragmatically framing a collaboration of cluster actors.

It potentially enables the identification of competences (see Section 3.3 below) and innovation functions (Section 3.2) which apparently are lacking in particular kinds of firms in the context of the specific drivers for competition and innovation that prevail in a given cluster. A cluster approach lends itself to the identification and resolution of 'institutional mismatch' within the cluster system of innovation:

- Assets and resources that are invisible to certain actors
- Communications that fail to occur
- Misunderstandings, inaccurate stereotypes
- Inappropriate expectations or evaluation frameworks.
- Etc. See the synthesis report for RISE workpackage 3 (Norgren & Hauknes, 2000) and Appendix 8 to the present report: *System failures*.

On this basis potential suppliers of relevant services might be identified, and the match between suppliers and potential users facilitated through the collaborative actions of various cluster actors.

Within RISE 'cluster' operates as a reduced scale innovation systems concept. As a system of innovation, a cluster is not so grand - or so abstract - as a national system of innovation. A cluster system is 'reduced scale' in the sense that it represents a real 'piece' of the global economy rather than a 'whole' (national) economy. However, it is not small in the sense that it must be contained within a national boundary; clusters that are significant for policy will tend to be transnational at least in part (unless protected national markets are a feature of national industrial strategy). Being defined in terms of collaborations and dependencies rather than an abstract reality such as a nation, a cluster has operational reality and practical significance for actual organisations. This makes the cluster level of analysis a potentially powerful focus for strategic collaborations between actors: clusters can be 'seen' in the real world by cluster participants. This pragmatic criterion is important in constituting the value of a cluster-oriented approach to policy analysis.

Mapping the dynamics of innovation clusters - mainly through qualitative methods such as interviews - leads to a focus on agents who may support positive dynamics and styles of innovation. RTOs are examined in this context. Especially, identified 'drivers' in a cluster, as they bear upon firms and other organisations differently positioned in the system, constitute economic

motivations for actors to participate in services, networks and strategic, policy-oriented collaborations.

3.1a Clusters compared with other approaches

In the RISE context a cluster is addressed as...

- a system of **organisations** with various institutional forms (firms, but also education institutions, government institutions, private non-profit service organisations and so on)...
- actually or potentially collaborating for purposes of achieving **innovation in firms**. Identifying potentials for collaboration is an important characteristic of a cluster approach. But in order to be a policy-relevant concept, a cluster must be a system that actually contains at least some existing networks of collaboration. It is not a useful commitment of policy time, to attempt to create a cluster from nothing. Thus clusters are not only emergent (selected for policy attention because they are developing, becoming more significant in scale and scope, have unfulfilled potential) but also emerging (actually existing 'on the ground' at some identifiable level of scale).

Verbeek (1999:2) suggests that there are two basic modes of cluster analysis: one oriented to the interdependency of numerous different types of organisations and another oriented to similarities between firms and their requirements. An approach to innovation clusters in the first (interdependency) mode assumes that economic activities cluster together because dissimilar actors need each other's competences in order to successfully operate and create innovations. The orientation of RISE cluster definitions is interdependency rather than similarity of firms (ie, their common infrastructure, similar operational needs, common framework conditions, shared factor or customer markets); or some particular geographical scale of organisation that is relevant to straightforward physical resource-sharing (neighbourhoods, districts, etc).

The envelope of a cluster is determined contingently in relation to its...

- **core members** (who may be firms or other institutional types - for example, public R&D institutes; the firms may be in manufacturing sectors - eg auto components - or service sectors, eg book publishing); and
- the context of **interaction and mutual dependency** that is constituted by the interest that these actors have in...
- a **domain of technological innovation and diffusion** (eg a diffusion system for biotechnology into traditional industries, or an emerging set of generic technologies such as information and communication technologies or multimedia) ...
- or a **market** (eg a value chain for processed food products or books or auto gearboxes). Markets - like collaborations - may be established or emergent; but a cluster in our sense does not exist as a meaningful focus for strategic intervention and policy until at least some level of market activity has actually emerged.

On this basis there is no standard formula for generating a cluster analysis. Identifying and analysing a cluster is a contextual, current, reflexive and evolutionary research process. As with any systems analysis, the boundaries and membership of a cluster are determined reflexively and iteratively by the standpoint(s) of the actors for whom the analysis is being developed, and their evolving perception of the structures, processes and relevant behaviours of the system. Thus a cluster boundary is determined analytically partly by the perceptions of core cluster members: a cluster is a 'real piece of the economy' pertinent to the span of innovative activity of some real

actors. The pragmatic criterion is again important: identified on this basis, a cluster provides an organising analytical framework for actions by actors in the cluster, including government and other organisations that feed, service, potentiate and draw upon the activities of the core actors.

The cluster approach mainly is an alternative to the traditional sectoral approach. Differences between a sectoral and cluster approach (not exclusively focused on innovation) are sketched in Table 1, following OECD (1999b).

Table 1 **Traditional sectoral approach vs. cluster-based approach**

Sectoral approach	Cluster-based approach
• Groups with similar network positions	• Strategic groups with mostly complementary and dissimilar network positions
• Focus on end-product industries	• Include customers, suppliers, service providers and specialised institutions
• Focus on direct and indirect competitors	• Incorporates the array of interrelated industries sharing common technology, skills, information, inputs, customers and channels
• Hesitancy of sector members to co-operate with rivals	• Most participants are not direct competitors but share common needs and constraints
• Dialogue with government often gravitates towards subsidies, protection and limiting rivalry	• Wide scope for improvements in areas of common concern that will improve productivity and increase competition • A forum for more constructive and efficient business-government dialogue
• Search for diversity in existing trajectories	• Search for synergies and new combinations

Source: OECD (1999b: 13)

Because cluster is a systemic notion, different interpretations of cluster may be adopted (as they have been in the RISE cluster studies) in order to deal with differently framed problem situations. Jacobs and de Man have analysed this in terms of a 'menu' approach to what is wanted from a cluster analysis, yielding differently formulated cluster identification 'recipes' (Jacobs & de Man, 1996). Seen in this way there are numerous related concepts in the field of innovation research and innovation policy which may be complementary to 'cluster' in the RISE sense, rather than mutually exclusive. These include: industrial districts & other agglomeration-based cluster approaches (RISE clusters are not defined by geographical agglomeration); development & growth poles, development blocs, competence blocs; value chains, supply chains & filières; industry cluster, industrial complexes & technological systems, resource areas; national innovation systems, innovation networks, and sectoral systems of innovation and production. The synthesis report for RISE workpackage 1 (Whalley & den Hertog, 2000: Table 2.5) compares these concepts.

RISE is about innovation as distinct from competitiveness: ie technological and non-technological innovation (not just technological innovation) looking particularly at the mix of manufacturing and service functions (to avoid the traditional divide between manufacturing and service activities). Porter popularised 'cluster' as an analytical and policy concept grounded in competitiveness. In contrast, RISE is mainly interested in how innovation comes about. We have

been concerned that both technological and non-technological innovations should be included in our span instead of only focussing on technological product innovations that can be evaluated for competitive advantage.

Elsewhere within the RISE analytical framework (workpackage 5, a micro-level analysis of the supply of 'competences' through innovation services) we are more directly concerned with competitiveness. A competence is defined as something that determines a firm's competitiveness: see Section 3.3a below. However, our primary interest in competences is their production and supply; and thus we focus on changes and dynamics in competences, and the ways in which they are passed between and distributed across systems of firms and other organisations. We are not primarily concerned with the strategic evaluation of the competitiveness of firms in the classic Porter fashion. In other words, the micro-level 'competence' analysis is consistent with the meso-level 'cluster' analysis: both focus primarily on innovation, change, dynamics and trans-organisational systemic characteristics rather than structural issues of competitiveness and positioning for individual firms. The micro-level analysis in fact extends the cluster rationale (dynamics, systemic failure, traded and non-traded linkages, manufactured and service outputs, etc) into micro- rather than meso-level phenomena.

RISE does not focus on some predetermined geographical scale - the nation, region, district. It is remarkable to see that some complete production clusters are strongly localised, e.g. dredging in the Netherlands, microelectronics in Silicon Valley or Biotech in Bavaria. However, starting from value chain based clusters one can equally come across clusters that are functioning at a national or even international scale or where some localisation goes hand in hand with very internationalised links. It may also differ for the various types of players within a cluster. Very localised players that operate in a local setting can be co-located with actors that are almost by definition internationalised and behave accordingly. It is even thinkable to have a local production cluster that is steered (in economic terms, in terms of where the technology comes from, in terms of major clients) by foreign players. Within RISE the choice was made not to exclude beforehand these types of international linkages. Some of our clusters (UK book publishing and printing, Swedish biotech transfer, Italian telecoms) were selected for analysis because they display this kind of transnational characteristic, posing questions about the role of a 'national' RTO.

Networks are essential for the functioning of clusters. These might be based on trade or non-trade linkages such as social networks, innovation networks, technology-based networks, learning networks, networks of pre-competitive cooperation, trade associations, professional associations, planning bodies, etc. In a cluster most likely various networks are in operation at the same time (clusters as 'network of networks'). Some firm-to-firm networks (which might be addressed as 'micro-clusters') may develop into complete clusters. Cluster can be regarded as the 'field' of potential and actual collaborations; within this, networks are actual collaborative systems of linked organisations, which crystallise within the cluster field. For practical purposes, there is no cluster that should be studied unless there are at least some actual networks. Clusters should not be 'invented' on paper.

Box 2 Distinctive characteristics of the approach to innovation clusters adopted in RISE

- *Pragmatic construction of clusters - 'artificial' boundaries related to policy aims rather than 'natural' boundaries of a current economic-geographical system of exchange are decided mostly together with cluster actors*

- *A focus on interdependencies and linkages (traded and non-traded, firm and non-firm, actual and potential, cross sectoral)*
- *An analytical focus on innovation, even if a production system (value chain) has been adopted as the initial identification of actors and links*
- *A focus on the construction and dynamics of the relationship between commercial innovation services and the public knowledge infrastructure*
- *A perspective which may cross various geographical scales (not just remain within localities)*
- *Mostly qualitative (but may exploit statistical analysis)*
- *Not just an 'offline' analytical tool - also a practical way of organising policy formation and implementation*

3.1b Actors who are more and less central within a cluster

What kinds of actors can be observed within the RISE clusters? A wide variety of actors are present, ranging from companies to domestic or internationally orientated research institutes to government departments. Actors fall mainly into one of three broad categories:

- *Research & education institutions* – included within this category are **universities, KIBS firms** and **RTOs**. They provide research-related input into the innovative process. Universities also provide an educated workforce that can be used by actors within the cluster; RTOs sometimes share aspects of this role related to postgraduates and career development for qualified professionals.
- *Actors who shape the environment in which innovation occurs*. This occurs through the actions of **government departments** in the host country. **International organisations** also have effects on the cluster environment.
- *Companies*: **domestic-oriented firms** and **multinational enterprises** (MNEs). However, some companies provide a range of intermediate inputs while others specialise; some occupy a key position in the cluster because their input(s) to others are unique. Significantly, this is true not only for companies but the other two broad categories of actors identified as well.

Our analysis of firms in the Portuguese biotechnology cluster (Fontes, 2000) suggested another classification for firms, depending on how active they are as participants in the cluster, deploying key technologies:

- *Watchers* – companies not prepared to apply new technology directly to their business activities, but engaged in some related projects to gain awareness.
- *Marginal users* – companies neither actively adopting nor incorporating new technology into their business activities, but taking it up passively, ie in response to other actors.
- *Core users* – companies who have actively sought to adopt and incorporate the new technology into business activities. The new technology is central to the business activities of the company; business success is closely associated with the success of the technology.

The most dynamic actors are core users, the least dynamic are watchers. This scheme may be a way through which changes over time can be tracked.

Another dynamics-related classification of actors is in terms of core/periphery participation in the cluster. The study of the Dutch multimedia cluster (den Hertog, Brouwer, & Maltha, 2000: 10)

divides the cluster into a core and a surrounding rim. Both core and rim are not homogenous, populated by various types of actors. The core contains between 500 and 1000 companies whose principal activity is related to the delivery of content, independent of any particular media platform. Cooperation occurs because each company provides some specialised form of knowledge or content. In the rim of the cluster, companies are established players in one or more of the markets that supply inputs to the multi-media cluster (for example, the broadcasting sector or the telecom supply market). Such companies cannot develop all aspects of a multimedia service alone, although their move into other markets is increasingly taking on this trajectory. The diverse inputs required for multimedia development and the lack of rim companies active in all markets ensures that no cluster 'directors' or 'regisseurs' exist. But it is likely this will change in the near future as some firms acquire others within the cluster.

The German study of the automobile component-manufacturing cluster offers a further way to classify actors shown in Table 2. The innovative company is placed at the centre of a web of inter-relationships that link cluster participants together. Other cluster actors include customers, suppliers, RTOs and KIBS firms and government agencies.

Table 2 **Classification of actors within the German automobile component-manufacturing cluster**

Category	Salient characteristics
Innovating company	Centre of the cluster.
	Innovation part of overall product or performance strategy
Customers in the automobile company	Linkage role – between suppliers' markets and the market for vehicles.
	Active role in determining course of innovation
Suppliers of parts and raw materials	Provision of key elements of the innovation to the central company.
	Close and Important linkage with manufacturers.
RTOs	Provision of specialist technology relevant to the innovation.
	Closely linked to universities.
KIBS	Role of small task sub-contractors within the cluster.
Business services	Marginal contribution to the innovation.
University academics	Specialist knowledge contribution from within the university environment.
Agencies	Intermediaries transmitting information between other cluster actors.
	Stimulation of innovation through highlighting issues.

Source: Preissl (2000a: 31)

These schemes all emphasise that inter-relationships within the cluster are not the same; they differ not in strength but also intensity. Some actors are more active than others, identifying the need for innovation and guiding the innovation process while others funnel information from one party to another. With respect to R&D, the German analysis distinguishes between actors who are 'R&D active' and 'R&D passive'. This mapping is consistent with the approach to innovation systems mapping outlined above in Section 2.2, Figure 3. There an innovation system

was represented as a system of actors constituting a 'manifold of services' to firms - who may or may not innovate, and may or may not avail themselves of (tacit or explicit) services external to their operational supply chains. This type of analysis also comes close to supply-chain structural analysis, as displayed for example in Durham University's analysis of SME strategies in different locations in global supply chains (SME Foresight, 1996). This approach to 'centralness' and selective partnering within innovation trajectories might be seen to have similarities also with Pavitt's classification of firms with regard to their differing external sources and trajectories of innovation (Pavitt, 1984).

3.1c Subclusters and national scale

In some cases subclusters are identified within clusters. For example, the core activities of the Portugese and Swedish biotechnology clusters were identified at a level well upstream in the flow of biotechnology innovations from basic research to industry. In both cases, subclusters are identified further downstream in which actors and strategies are quite different from each other - food, pharmaceuticals, forestry, etc. In the Portugese cluster's food subcluster (a traditional industry) 'watchers' and 'marginal users' dominate the scene; this differs markedly from pharmaceuticals (where 'core users' are significant) and again from the (mature industry) forestry and pulp subcluster. It is for this reason (seeking a more homogeneous cluster setting) that the UK study focused on a subcluster only: book publishing and printing, within a far wider cluster setting which might variously - and for different purposes - be identified as printing and publishing, or multimedia.

Although clusters are not limited to a national context, for some the local dimension is quite solid. This will vary according to which part of the value chain actors operate in. For example it is possible to confront the multimedia and the telecommunications clusters from the standpoint of individual countries. On one hand, in telecommunications there are mainly elements not affected by national cultures: network technology for example is increasingly international and the specialist technology suppliers are seeking to dominate their market segment worldwide. On the other hand, the multimedia cluster - the content component - is bounded by national cultures (not least, national languages). Therefore, it may make sense to talk about a Dutch multimedia cluster, but it is impossible to identify an Italian telecommunications cluster.

3.1d RTOs in clusters

Preissl (2000a: 9) shows that RTOs in the auto components cluster vary in both size and budget. There are small RTOs having fewer than 20 researchers and larger ones between 70 and 100 researchers; in other sectors/countries RTOs may be extremely large. In the UK for example, the National Physical Laboratory has 650 staff, the Central Laboratory for the Research Councils has 1700, Inspectorate (ex-British Standards Institution) has 2600; all are members of the Association of Independent RTOs. Some German RTOs are comprised of engineers and university level qualified employees, while others are almost all academics. The budget of smaller RTOs in the German auto components cluster falls between 1 and 3 million DM, whilst that of medium budget RTOs varies between 70 and 100 million DM. Finally, some of the identified German RTOs focus on automotive technologies while others specialise on a particular technology which happens to be applicable to the automotive industry.

Three functions occur most frequently in RTOs featuring in our cluster studies: publishing, linking with universities, and R&D.

Publishing: The Swedish study (Backlund, Häggblad, Markusson, Norgren, & Sandström, 2000) draws attention to the role of RTOs in disseminating information to cluster members. The Swedish Institute for Food and Biotechnology (an institute owned by industry members) actively disseminates information through knowledge transfer networks as well as co-ordinating external research programmes and publishing of journals and newsletters. The main RTO in the UK book publishing and print cluster not only supports publishing and printing firms but has diversified into substantial information-publishing activities (trade and management handbooks, best-practice guides, surveys, etc) in an alliance with one of the main trade associations, the British Print Industry Federation.

Linking with universities: Differences in staffing, scale and budgets reflect the different activities that RTOs perform within the cluster. Some of the RTOs in the German auto components cluster are more research orientated than others (and in all the other RISE countries RTOs are more research oriented than in the UK). The closer the RTO to a university, the more research that it will undertake. Consequently, RTOs perform a mediating role: between basic research and universities 'upstream' and industry and applied research 'downstream'.

Changing roles: The UK printing and publishing study highlights the changing role of RTOs within clusters. The principal RTO in the cluster – Pira International – has evolved from a co-operative research association funded equally from state and subscription sources, fifty years ago, into a business consultancy offering services for most value added activities (Readman, 2000: 13). This has occurred in three complementary ways:

- Broadening the array of services. Pira International is no longer an applied research driven RTO concerned solely with 'hard' production technology; it has metamorphosed into a business consultancy company supporting workflow strategies, marketing strategies and supply chain strategies.
- Forming a strategic alliance with the British Print Industry Federation (BPIF). BPIF acts as a lobby organisation and disseminates information. In their joint venture both BIPF and the RTO share market intelligence while Pira publishes material generated by BPIF.
- Pira is broadening its service offerings from a traditional multi-sectoral focus on print, paper and packaging technologies - and latterly, digital technologies in publishing - to include publishing as an expanding in-house RTO activity. The shift to content-oriented services (and thus control over intellectual property) is a strategic challenge that faces Pira, itself a small player in the multimedia cluster.

Of these the first has altered the RTO most; the second and third are extensions. On the one hand Pira International is able to offer its clients a much broader array of services. On the other the RTO is becoming less like what is traditionally understood as an RTO and more like a KIBS firm.

The changing nature of RTOs is further shown in the Italian telecommunications cluster study. This showed that when RTOs seek to expand the scope of their activities they have a broad choice between two options:

- Expand the portfolio of activities though acquisition. Acquisitions may be of RTOs or commercial knowledge intensive research organisations. For example, SIRMI (a private research institute) acquired Crossover to gain specialised skills in telecommunications.
- Broaden the scope of their portfolios through consortia, joint ventures and alliances with other research organisations. These can be commercial or publicly funded. For instance, SIRMI entered into collaborative arrangements with CompUSA, Istituto Ricer International, Pin Venture.

The motive behind both strategies is the same: to expand the range of services/activities and enhance its competitive position. Expansion enables the RTO to better position itself in the market as the range of services more fully matches those desired by clients. This is clearly important if the market is rapidly changing with the consequence that the more established or traditional RTOs are increasingly unable to match their knowledge base with large and significant spans of activity in the telecommunications industry.

In the UK, strategies of alliance (eg between members of AIRTO, the 'sector' association) are visible but not (yet) acquisition - although a British RTO in the field of toxicology has recently been acquired by the large Dutch RTO, TNO as part of its food-related strategy. Publishing strategies are visible in the UK too - for example, moving to self-service web-based services for information publishing, dealing at lower cost with routine enquiries and 'frequently asked questions'.

It is quite possible for an RTO to be marginal in a particular cluster of innovating firms, while simultaneously being viable as a revenue-generating service producer. The print-and-publishing RTO in the UK book publishing cluster, for example, seems more marginal to core cluster actors than, say, the trade associations of publishers and printers (hence the value of an alliance with the BPIF); and all of these are less important to most firms in the cluster than the (mostly foreign) firms that manufacture and supply print, pre-press and workflow management technologies. Yet as an organisation the RTO is quite viable, because its activities are spread across a wide client base in several distinct sectors (which also may be viewed as clusters that are distinct from each other in many ways): printing, packaging, publishing, paper.

Box 3 **Lessons from RISE cluster studies**

- *Even with a semi standardised approach in terms of a common set of dimensions and questions the elaboration by the different teams was very different, also because research background and access to data sources varied.*
- *The cluster approach seems comes closer to the 'relevant context we work in' in comparison with traditional sectoral analysis.*
- *Identifying clusters can be seen as either a quite complicated technical exercise (for example, involving input-output analysis) or a practical question that is open for discussion in the beginning of a cluster study and which needs to be resolved through interaction between experts and practitioners drawn from within the cluster.*
- *Delineating the core of a cluster and its boundaries is, however, an extremely important issue and needs to be resolved when starting the analysis. If not, the question will keep reappearing as an item for discussion.*
- *Starting from a broad set of industries, expert interviews, snowballing from individual firms and institutions are all options for looking for the cluster boundaries.*
- *Some statistical evidence on how the cluster is performing is helpful.*
- *Before the dynamics of innovation services can be addressed (the RISE focus) substantial effort has to be invested in simply mapping cluster actors and cluster structures.*
- *Performing cluster studies is laborious: qualitative interviews are needed and only a few events to let people interact are worth investing in.*
- *'KIBSification' - Knowledge infrastructures and the balance between RTOs and KIBS are very different in different clusters, and much more subtle than RTOs getting more market oriented and KIBS taking over more functions usually associated with RTOs.*

- *Even within clusters operating at a national or even international scale small geographic nodal points of activity could be detected; and vice versa, most local clusters are in need of a few international links to keep going.*

- *The act of performing the actual cluster study is an ideal tool for policy-makers for bringing cluster actors together and for identifying possible policy options to strengthen the cluster.*

Unresolved issues

- *The lack of statistical material that is suited to cluster needs (or which can be only made available at great costs) is troubling cluster studies.*

- *Discriminating between new, upcoming, established and mature clusters is difficult. Pragmatics - which actors are interested in the different definitions - may be a deciding factor.*

- *How to deal with clusters that are nascent or almost extinct? (The Dutch multimedia cluster has been treated as 'adolescent'!)*

- *Other modes of knowledge creation, distribution and competence supply such as the training and mobility of qualified professionals and diffusion of machinery (and the services that go with it) are hardly touched upon in our present studies. Competence-supply case studies in the UK book publishing cluster and Norwegian food processing cluster include a focus on the latter, but none of the cluster studies focuses strongly on the former.*

3.1e Ten messages

Ten messages arise out of our analysis of clusters. It is tempting to see these as generic conclusions but this should be resisted. Some interpretations are grounded in all the cluster studies, others from a few. The messages are presented in Box 4.

Box 4 Messages from cluster analysis

1 Innovation seldom takes place in isolation but is systemic - ie takes place in networks and clusters. The notion of a cluster is centred on linkages between (firm and non-firm) actors needed for bringing about innovation.

2 Clusters are a recognisable level of analysis for most firms and also the relevant knowledge infrastructure. A cluster mapping formalises the 'world in which we operate and function'. However, the notion of a cluster – like an industry, a sector or a national system of innovation – remains an artificial construct, designed for some purpose and less well adapted for others.

3 The way knowledge is produced, diffused and absorbed (without implying a linear model of innovation here) is key to the success (innovativeness, adaptation capability, competitiveness, competences) of a cluster. Most of the time it is highly cluster specific. The way cluster actors interact and innovate differs between clusters. Innovation styles/patterns are different - for example, between sizes of firms, or different locations in value chains - even if drivers for innovation are similar. The most successful clusters are capable of putting in place, adapting and fine tuning mechanisms for knowledge creation and knowledge sharing.

4 In quite a number (but not all) clusters RTOs and increasingly KIBS provide all sorts of knowledge-related service functions that help actors in this cluster to innovate and to adapt. The mix of (knowledge-related) service functions that RTOs and KIBS provide differs per cluster as well as the balance between what services are provided by RTOs and what by KIBS. However, as a general trend RTOs tend to move more downstream providing more hands on and implementation like services, whereas

KIBS increasingly perform services that used to be associated with RTOs and universities only.

5 The role played by KIBS and RTOs and other actors in the knowledge infrastructure, and the balance between them, appears to be cluster specific. So we do not propose 'best practices' as the appropriate mode for a cluster approach. Innovation styles differs between clusters, so what works in one cluster does not automatically work in another. Through a cluster analysis policy-makers can be sensitive to the particular institutional factors and drivers that are at work, and adapt the way they for example steer RTOs in particular clusters.

6 The mechanisms and experience built up in clusters – no matter whether these are labelled as high, medium or low tech – are valuable in themselves and as long as clusters have built in mechanisms to renew and re-invent themselves in time this is a precious asset. Therefore, switching at great costs to artificially create new, voguish clusters might be a costly strategy from both a policy and industry point of view. It is easier to build on existing strengths – even in so-called low-tech clusters – than create new ones from scratch. In practice these mechanisms can be rather refined and very knowledge intensive in well-developed 'low-tech' clusters.

7 Taking clusters as a perspective might also mean adopting new forms of governance (eg new types of RTOs, specific KIBS services, more room for public/private initiatives) - which again may be rather cluster-specific. In one cluster policy actions can be limited to ensuring via regulation and fiscal policy that competition is sound; in another it might consist of various participant roles for government (demanding customer, technology foresight, creating the appropriate knowledge infrastructure, marriage bureau, benchmarking, looking after competition practices, IPR problems etc).

8 The previous point also implies that capabilities for civil servants putting cluster policies into practice are changing. They increasingly need to be able to act as sparring partners, organise dialogue, manage or commission services, etc.

9 Cluster analysis and cluster policy then is a way (working tool) to customise broad 'framework' platforms of innovation and other policies towards the specific needs (and self organising capability) of a particular cluster.

10 The action of performing cluster studies in itself can be a strategy for starting or contributing to a dialogue on how innovation takes place and can be facilitated in cluster.

3.2 RTO roles and trajectories

In our whole investigation there has been an evolving tension between function-based and institution-based interpretations of activities in systems of innovation. It turns out that the discrete and rather abstract 'innovation functions' used in our survey mapping of RTOs and KIBS firms do not provide enough resolution to discriminate between the institutional types - RTOs and KIBS firms - or between types of RTOs. To distinguish the practical functions served by different types of RTOs we have found that we need to examine other characteristics of their output such as: who they compete with, who their clients are, what their relationships with their clients are, and what constitutes an innovation in their client's cluster setting. These all relate to the positioning of the service supplier organisation in its institutional setting - that is, they are related to the institutional location (and perhaps also the institutional form) of the organisation. Thus it seems that the opposition between innovation function, operational location and institutional form may have been a false one. In a sense, every effective 'systems' analysis of a

socio-economic system is both institutional (identifying the main 'organs' of a viable 'body politic') and functional (identifying what characteristically happens, and how).

One original aim of the RISE project was to discuss the evolving relationship between RTOs and KIBS firms. Tacitly we assumed that some process of 'KIBSification' was occurring in RTOs. It was further assumed that differences between RTOs and KIBS could be identified at the level of the functions they furnish to firms in support of innovation (ie their outputs) rather than simply at the level of their institutional characteristics (the 'publicness' and 'privateness' of their inputs and their internal processes). This was tested through a survey of RTOs and other organisations providing technology-related innovation services. Much of the present section is based on the synthesis report for RISE workpackage 2 (Preissl, 2000b) which includes an analysis of survey results. Please refer to that report for further detail and displayed results of our survey analysis. Other sources for the present section are our cluster studies and case studies. Issues outlined in this section are explored in greater detail in Appendix 7 to the present report: *The trajectories and roles of RTOs and KIBS firms*.

3.2a RTOs and KIBS firms

In our investigation we have distinguished between KIBS as function and KIBS as institution, and focused on function. Institutional characteristics of KIBS *firms* have been moved to the margins of our study.

'KIBSification' now appears as a strategy issue with three components:

i) **Governments** who increasingly distribute their activities across networks of public, private and hybrid organisations (semi-public agencies or franchises, chartered organisations with public missions and non-commercial management arrangements, etc). They shift away from *institutional* core funding (for RTOs etc) and towards *'functional'*, targeted contracts and programmes;

ii) **KIBS firms** who participate in markets for public contracts and public funding (eg precompetitive R&D, service contracts for government departments), competing in areas where RTOs traditionally may have had privileged status; and

iii) **RTOs** who become commercialised as they come to depend on an increased proportion of non-government revenue, competitively won in markets for services or public programme funding.

It is the publicness of RTOs that is their core interesting characteristic. RTOs performing contract research for firms remain different from KIBS firms precisely because they receive government core funding, or have public charters that prevent (enable) various courses of action that are open (closed) to independent firms. As actors in an innovation system, they can mobilise different resources and move in different ways.

Competition between RTOs and KIBS seems not to be based on a division of labour with different institutions specialising in specific functional domains. Both RTOs and KIBS range across the full range of functions in our classification. Competition is contingent on the structure of markets and clusters, the drivers of competition in a cluster and the mix of innovation and competition strategies ('innovation style') adopted by various actors within clusters.

The analysis of innovation functions does not provide convincing evidence of a strong division of labour between KIBS and RTOs in the 'downstream' areas related to activities within firms. This division is clearest in our UK responses (where ex-RTOs contribute to a strong 'downstream' profile in non-public innovation services which contrasts with the profile of organisations that

remain under public funding). But the profiles of KIBS firms in some of the downstream areas in other countries are surprisingly low. Our samples may be at issue here, since sampling of KIBS firms has a much less systematic basis than sampling of RTOs in these countries (reliable lists of public-funded RTOs are available). Also, the definition of innovation functions related to organisational change, markets, brands, forms of business organisation or business strategies is not well developed in our classification of functions. The classification is manufacturing-biased and does not well reflect the enhanced range of innovation processes (and services?) that would be associated with innovation in services as distinct from manufacturing. These are issues to be dealt with in the design of future surveys. At the present time we have to conclude that our results provide only limited evidence of either an expansion in the range of innovation functions being provided or a very marked division of labour between RTOs and KIBS in providing those functions that have been mapped.

A division of labour between public and private organisations is clearer in the UK than elsewhere. Ex-RTOs now operating as UK PNP companies more frequently offer functions that are further 'downstream' than public organisations in the UK and RTOs in the other countries. Also, there is a much greater gap in the UK than in the other countries, between the proportions of public organisations (government labs, universities) and private organisations (full KIBS, PNPs) that offer a given function.

3.2b Changing roles of RTOs

We surveyed RTOs in six countries. Our results show that the mix of RTO outputs to various broad sectors or economic communities is shifting, especially between 'public' services (to the scientific community and the skilled professional workforce) and contracted services to individual client organisations (firms, governments). A defining characteristic of RTO trajectories in current systems of innovation is a continual increase in their traded activities, relative to their public-funded ones.

The full commercialisation (privatisation) of RTOs by government is a rare strategy. The UK sample provides our only case. In Sweden, Germany, the Netherlands and Portugal between one-half and three-quarters of labour expended in RTOs is committed to 'public' outputs in the scientific community. Basic research is one of the two most frequent innovation activities supported. RTOs continue to receive core funding and programme funding on this basis. The UK and these other countries differ in their distribution of functions across institutions, and this is a durable historical characteristic of different national innovation systems: the difference in public/academic emphasis existed prior to the commercialisation of UK RTOs in the 90s.

Although RTOs perform more traded activities now than before, their level of activity in services to clients - firms and governments - is still not necessarily very high, compared with their involvement in scientific research or training. RTOs in Sweden (where universities perform many 'RTO' functions) and private non-profit ex-RTOs in the UK differ from our other samples of RTOs in having a high proportion of labour allocated to contracts for industry: 50% average, 1999 values. In contrast, RTOs in Germany, the Netherlands and Portugal commit only around one-fifth of their labour to these outputs (risen significantly in the Netherlands and Portugal from around 10% in 1995). On this measure Swedish and UK RTOs approach the degree of industry orientation typical of KIBS firms in Germany.

On the measure of outputs to government as a client ('policy consulting') Portugese and Swedish RTOs score very low: less than 5% of labour allocated to this output. The level of policy

consulting in the UK fell from 1995-1999, by a proportion (roughly 10%) equal to the increase in labour allocated to industrial contracts. Even so, the level of labour associated with policy consulting in UK ex-RTOs remains higher (greater than one-quarter) than the levels in German and Dutch RTOs (around one-fifth).

In Norway an average of about one quarter of RTO turnover (1999) came from foreign sources. In Swedish and German RTOs foreign revenue is much lower, around one-tenth of turnover, slowly rising. Dutch and Portugese RTOs had levels similar to Norway in 1995, falling in 1999 but expected to rise again by 2002 (to 28% in the Netherlands, 20% in Portugal). The level in the UK is about the same, at around one quarter for both RTOs and ex-RTOs. Our data cannot tell us how much of the foreign turnover is government funding, and how much is industry contracts.

3.2c RTO product trajectories and the governance of RTOs

Upstream and downstream functions

RTOs display a mild movement towards the more 'downstream' (market-facing) functions in our classification of innovation functions. The classification is shown in Table 3. Nevertheless, 'implementation of innovation', 'planning, project management, personnel management' and especially 'introduction to the marketplace' all score low on the list of functions they provide or support. In contrast, 'basic research' and 'product/process development' score high: presumably product/process development is understood to refer to the more upstream domain of design and engineering rather than the downstream activities of operational implementation. Table 4 shows the relative frequency with which different functions were supported by RTOs, on average, across our national samples of RTOs.

Table 3 **Innovation functions as surveyed by RISE**

Basic research, procurement
Acquisition and study of necessary information
Feasibility studies
Product development/procedural development
Planning, project management, personnel management
Construction of prototype
Testing
Implementation of innovation in the innovating company
Documentation and certification (including patenting)
Introduction into the marketplace

These results show that the most frequently offered functions from RTOs in Germany, the Netherlands and Sweden were basic research and product/process development. However there are differences: all RTOs in the Dutch sample offer basic research as a function, compared with 60% of German RTOs. Basic research was also the most frequently offered function by public organisations in the UK (government labs, universities) but was offered by only a half of PNP companies (private non-profit, commercialised ex-RTOs) and KIBS firms. This level in turn is substantially higher than in the equivalent category in Germany which contains relatively few PNPs. At the other end of the scale - in terms of both the incidence of the function in our RTO samples and a linear model of innovation - lies introduction into the marketplace. This function was the one provided least often by German, Dutch and Swedish RTOs (offered by fewer than

one-fifth of the sample). In contrast, the function was offered by half of UK PNP companies and KIBS firms, a level higher than for German and Swedish private firms in the sample. UK government labs and universities also offered this function, at a level equivalent to the German KIBS sample and a much higher level than German, Dutch and Swedish public RTOs.

Table 4 **Frequency of offering the functions of Table 3 - German, Dutch & Swedish RTOs, banded as high, moderate, low**

HIGH FREQUENCY
Basic research, procurement
Product development/procedural development

MODERATE FREQUENCY
Acquisition and study of necessary information
Feasibility studies
Construction of prototype
Testing

LOW FREQUENCY
Planning, project management, personnel management
Implementation of innovation in the innovating company
Documentation and certification (including patenting)
Introduction into the marketplace

Source: Preissl (2000b)

As Table 4 shows, RTOs concentrate their activities more in the 'upstream' regions of the innovation process, with less involvement in implementation. In the UK both public and private organisations show a more even spread across the whole range of functions. In particular, testing, planning etc, implementation, documentation etc and introduction into the marketplace are offered much more frequently by all organisations compared with the German, Dutch and Swedish samples while product/process development is offered less often. However, when this last category is subdivided (this was not done in the other national surveys) it can be seen that more than four-fifths of both public and private organisations in the UK sample offer product development, while three-quarters of KIBS/PNPs but only two-fifths of public organisations are involved in process development and organisation development.

Systems of semi-public RTOs increasingly contain RTOs - or operating units within them - that are more downstream oriented. However, such responses seem to be dealing with 'technical' innovations, oriented towards the practical *integrating* of different specialist technical competences to meet specific client requirements. They probably are not focused to any great degree on generating and integrating 'market' or 'managerial' innovations alongside technical ones.

Traditional and non-traditional functions

The 'traditional' range of RTO services may be interpreted as *explicit non-traded innovation services*; pre-competitive R&D funded by government provides the paradigm for this band of service

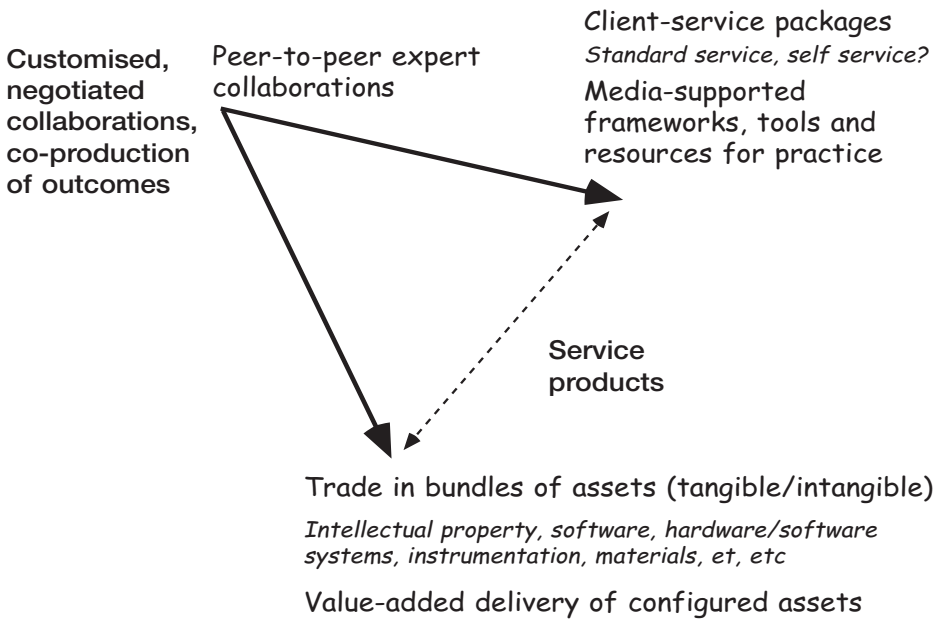
activity. Expansion beyond the traditional range then can be interpreted as adoption of services which fall in 'traded' categories: traded intangible innovation services (eg workflow restructuring, certification, organisational change; also trade in intellectual property assets) and traded tangible innovation services, such as prototyping, or the configuring and roll-out of configured (software?) systems. In these terms, RTOs clearly are extending their traditional range. We can identify cases in which RTOs have extended their activities into traded intangible services on one hand (eg information services related to R&D) and traded tangible services on the other (eg the supply and implementation of applications software). Although these examples show various extensions of the range of functions furnished by RTOs (ie, further downstream towards the clients' context of application) their common characteristic is that they involve RTOs in trading rather than the production of public goods. In other words, in these areas of activity RTOs are functioning as contract research organisations rather than producers of public-good outputs. The great majority of RTOs are involved in both regimes of funding and production; but a defining characteristic of the RTO role in current systems of innovation is a continual increase in their traded activities, relative to their public-funded ones.

A traditional function of RTOs and a major part of the rationale for government funding is to provide cooperative or collaborative services to particular populations of firms. Neither type of service necessarily requires an RTO to be core funded by government. On one hand, a subscription to cooperative services (eg passive dissemination of research results generated by the RTO) may simply provide a 'bulk discount' on a standard information service otherwise available at market spot-contract prices. Such services may be seen as elements of an information services market, requiring no public funding except perhaps for pump-priming pilot projects for new modes of presentation in low-cost information services. On the other hand, collaborative, pre-competitive R&D is frequently funded through competitive public programmes in which consortia including RTOs may make bids. Consortia containing RTOs may or may not be more successful in such bids(we cannot tell from our data) but being an RTO is not a condition for gaining such funding. An exception lies in some programmes designed to correct system failures, where RTOs as 'industry-facing' organisations are a defining element of the project mix. The aim of such projects is to bring different institutional actors - RTOs, universities, firms in a cluster - into new working relationships and promote awareness of potential innovation and market opportunities. However, an explicit cluster rationale is not necessarily a part of such schemes; explicit cluster strategies (in the RISE sense rather than the regional sense: see 3.1a above) are quite rare.

Two trajectories: asset packages and 'interpreted resource' packages

Two broad trajectories can be sketched for a traditional public-funded RTO moving towards greater reliance on delivered services to generate revenue. A first non-traditional trajectory - asset packages - will have the RTO generating configurations of assets which can be traded as intellectual property or as tangible products (instruments or diagnostic equipment, standard software, specialised materials, etc). An alternative trajectory - 'interpreted resource' packages - will lead an RTO from peer-to-peer dialogues and expert collaboration towards client services supplying packages of symbolic and intangible resources such as models, conceptual tools or trainings, which may be integrated into the client organisation through 'cultural' processes of interpretation, conceptual integration and genre-building. The trajectories are represented in Figure 4.

Figure 4 **Two trajectories for a traditional RTO**



Both trajectories imply change in the basis on which an RTO is evaluated or governed; or at least, the governance of the activities that comprise the new trajectory may need to be established in a different mode than the traditional one. The assets-package model of activity involves generating configurations of tangible or intangible assets. The rules of traditional RTOs may forbid this kind of activity. Changed guidelines rather than changes in legal articles can sometimes be enough. Otherwise it may be appropriate to separate these activities by creating an institutional boundary and applying a distinct form of governance to the new organisation and the interface (eg creating a spin-off firm with an intellectual property ownership agreement or royalty agreement). It may be possible to accommodate the governance of the new activities by structural changes within the existing institutional framework (eg by creating specialised operating units within the organisation, answerable to a different rationale and supported differently with inputs).

The interpreted-resource model of activity involves configuring various systems of resources and interpretative practice - stories, images, small-scale genres of activity, schemas, etc - into routinely deliverable configurations (live 'performances in repertory', downloadable information products, etc). Such outputs typically are not rewarded by professionalised research fields, and especially, by usual academic criteria. The labour required to establish a workable and repeatable mode of service delivery with a community of non-university, non-researcher technical practitioners may be substantial and will generate opportunity costs in relation to more traditional activities. This kind of risk can be hard to support in RTOs where their expansion into industrial services is evaluated on the crude basis of achieved turnover in service revenues, and 'rewarded' simply by further cuts in core funding. Other cultural and financial reward systems need to be considered.

We cannot tell from our survey evidence whether the routinisation of outputs - either asset/commodities or cultural/interpreted packages - is widely pursued as a strategy in our

sample of RTOs. Our investigation has had a bias - in the sampling of micro-level case studies for example - towards 'strategic' collaborative services that generate large-scale, significant competences for their clients. 'Small services' and self-service is an area that needs further examination from a policy standpoint. Most RTOs must operate in the future under regimes of reduced core funding and competitive programme funding, where they still remain obligated to deliver services to populations of less-competent national firms. It is clear that as part of their future business mix at least some business units of some RTOs will therefore need to pursue routinisation strategies, productisation strategies (both 'hard' and 'soft' products, and hybrid product-service packages) and self-service strategies.

There has been an unintended bias in the selection of cases for micro-level analysis in RISE. In our concern to explore issues about the size and scope of services and the size and scope of effects, we did not select enough small, simple ones: the supply of standard answers to frequently asked questions, routinised (perhaps automated) services, self-services. Consequently, we have not been able to explore sufficiently fully the contributions that formal codification makes to the ability of self-service arrangements to do useful work for clients (in relation, for example, to the literacy of the user community); or the ways in capitalisation (asset infrastructures: software, machinery , documentary assets) make routine services viable for both supplier and client. These are dimensions that should be carefully explored in further research within the competences/assets/resources framework.

The roles and trajectories of RTOs and KIBS firms are discussed in more detail in Appendix 7 to this report.

3.3 Service deliveries in an economy of competence supply

In addition to studying interactions between RTOs and client firms, at the level of linkages within innovation clusters, RISE has also carried out case studies of the interactions that constitute the process of service delivery. This level of analysis had three aims:

1. To complement the meso-level analysis of clusters and RTO functions with a micro-level analysis of innovation service-products, service delivery events and their management.
2. To explore and evaluate a conceptual framework based on 'competence' as distinct from 'knowledge', as a way of analysing the content and management of knowledge-intensive business services; and specifically
3. To identify and illustrate some significant features of translating, producing and substituting competences via service delivery events.

More informally, we can say that this level of analysis is concerned with the *doing* of innovation services. We are seeking a conceptual framework to describe not just what innovation services do, in a structural sense, within the dynamics of innovating firms (ie, to describe 'innovations'). We also seek to describe the doing or active *performing* of a service, and how one performance (the service) determines another performance 'downstream' (competent action in a competitive environment). Our approach is through a concept of 'competences'; innovation services are interpreted as services that supply competences to firms.

We have made a distinction between 'knowledge intensive' firms (those relying heavily on qualified professionals: an input index) and knowledge intensive services, which we define in terms of competence supply (an output index). Our study focuses on characteristics of services (competence-supply interactions) rather than institutional characteristics of service suppliers (KIBS firms or RTOs). In the micro case studies we retain a focus on what innovation services *do*, and through our sampling we also allow the possibility of recognising other ways in which such outcomes are achieved. Thus our case study sample (ten cases situated in six cluster contexts) includes not only service interactions with firms by RTOs but also by knowledge intensive manufacturing and service firms and universities, some of whom supply innovation services that are tacit rather than explicit. This is consistent with the position taken in Section 2.2 above regarding the hybrid economy of tacit and explicit innovation services. We do not wish to smuggle in an assumption that the delivery of an explicit service is a primary or reliable route to competence. We wanted our cases to speak for themselves on this matter.

For more detail of our case study analysis than is presented in the present section, and an expanded discussion of the concepts that make up a 'competence' analysis, see Appendix 6 of this report: *Service deliveries in an economy of competence supply*. The appendix summarises the synthesis report for workpackage 5 of RISE (Hales, 2001), which is also available.

3.3a Competences, assets and resources

In the RISE micro-analysis context, a competence is defined as a systemic and systematic ability of a firm - or some operating unit of a firm - to do something which either:

- Enables or sustains participation in a market on a *'qualifying'* basis similar to other participants, allowing it to produce similar things and act in similar ways; or
- Inflects the business trajectory of the firm in relation to markets, competitors, costs, asset usage, etc, bestowing *'leading'* qualities on the firm.

In other words, competence is a strategic quality, defined in the context of evaluations of competitiveness and specific clusters and markets. Competence deepens the cluster-analysis logic of RISE. It takes to a more fine-grained level the contextual analysis of functions required by innovating firms in concrete settings.

The RISE interpretation of competence is notable because of the way in which it combines two aspects that other approaches do not. On one hand we deal with 'shippable' aspects of science- and technology-related services and encapsulated components of competences: tradable assets and objects such as configured equipment, prototypes, documents, software on platforms. On the other hand we deal also with 'performed' and interpreted elements of service and competence.

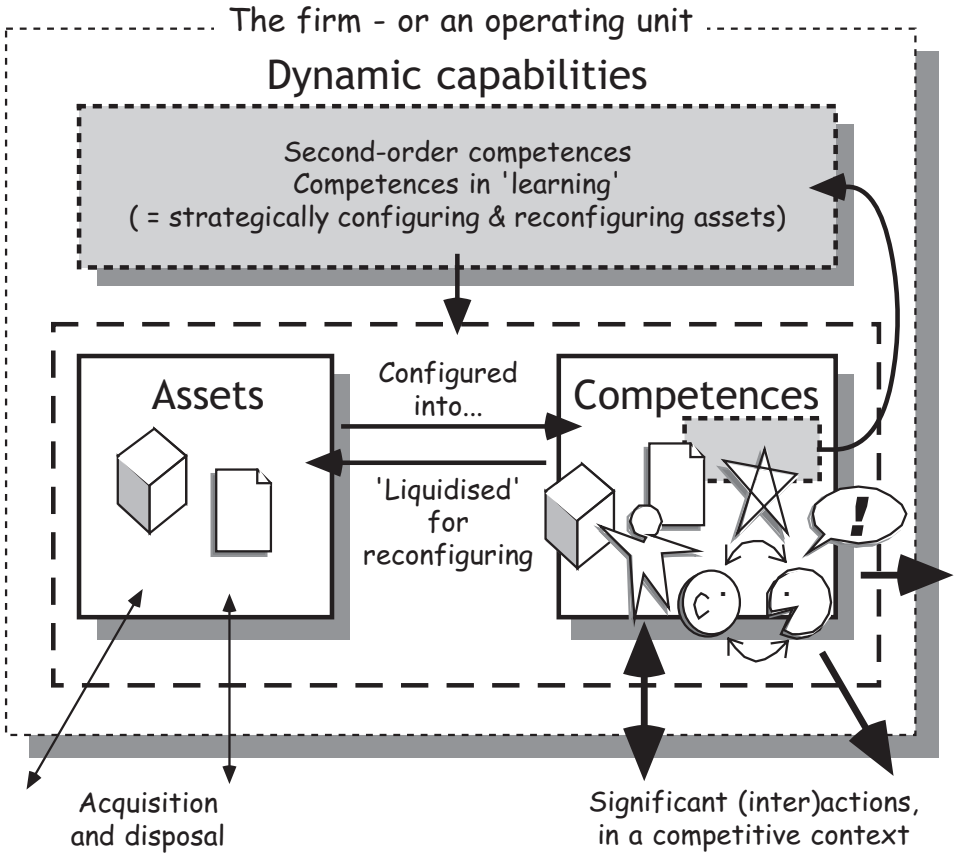
In our case studies a competence is treated as a collective, teleological property, a systemic capability of a concrete socio-technical system to achieve*.... this and this and this ... in this kind of context*. Competences are identified with behavioural properties of systems constituted by people in a firm, organised in the actual ways they are organised (including culturally, through shared languages, interpretations, professional identifications, common resources, etc), together with the firm's non-human assets and resources, also organised in a particular way. Assets as well as humans are culturally organised, via their participation in conventional usage within communities of practice, the symbolic qualities that are attributed to them and the value that they are credited with.

Competences are addressed under two aspects: as phenomena of purposeful and resourceful action within a situated, interactionist frame of reference (*the resource perspective*); and as

constructions of business strategy, in which humans are 'added to' concretely configured, exchangeable assets (*the asset perspective*). Assets are constituted by their tradability (and thus exist in contractual frameworks), resources by their availability and 'ready-to-hand' qualities of usefulness in the particular practical setting that they happen to be addressed in. Both perspectives may be applied simultaneously. However, the resource perspective is more fundamental. An asset perspective cannot account for how humans coordinate or act competently; rather, we have to refer to the ways in which resources are mobilised and structured in courses of action, and in turn, structure the future course of actions.

Although RISE creates a distinctive interpretation by superimposing the (sociological or anthropological) 'resource' perspective on the (economic) one of assets, our basic model of competence is fairly consensual within the field of innovation economics. We regard it as compatible, for example, with concepts of competence, the path dependence of innovation trajectories, strategic asset positioning, dynamic capability and asset 'stickiness' found in (Dodgson & Bessant, 1997; Leonard-Barton, 1995; Teece & Pisano, 1994; Teece, 1998; Teece, Pisano, & Shuen, 1990; Winter, 1987). We view competences as configured assets. Dynamic capabilities are 'second order' competences (ie competences that change competences). Figure 5 represents this model. The figure includes a reference to the 'resource' reality by showing that competences comprise not only assets but also performed and interpreted 'cultural' elements.

Figure 5 **Competences as configured assets; dynamic capabilities as second-order competences; competences as abilities to do significant things**



The icons constitute a link from the 'asset' perspective to the 'presentation mix' schema, a key component of the 'resource' perspective: see below, Figure 7 .

3.3b Delivering and seizing competences

In English there is a saying: 'You can take a horse to water, but you can't make it drink.' A similar proposition seems to have evolved in RISE, regarding the delivery of competences. Something like: *You can be a competence supplier but you can't necessarily deliver a competence to any given client*. This underlines part of the value of the 'competence' concept in addressing knowledge intensive services. It is too easy to assume that knowledge can be delivered; it may be less easy to assume this of competences. And competences - abilities to *achieve* things - as distinct from knowledges are what matter most for most firms (although not for firms who trade in knowledge assets - for them competences AND deliverable knowledge assets matter most).

As an alternative to 'knowledge', a competence-centred analysis of 'knowledge intensive' services can assist service users, providers and funders (in the case of government) to more adequately - that is, concretely - weigh up the scale and complexity (scope) of service from a public or commercial supplier that is required to contribute or contribute to a particular competence. Our case studies have shown that the 'delivery' of competences is in some ways problematic, But at the same time, by developing an analytical approach to what it is that such a service does 'supply' - in terms of the scope and scale of the interaction, and the scope and scale of the downstream 'memory' effects - we believe we have provided some tools for evaluating and handling competence-supply service products.

The resource aspect of RISE - taking account of performance and interpretation - is central in determining how we view the delivery of a knowledge intensive service. On the basis of our case studies we question the extent to which a competence can be 'delivered'. Instead we move towards a 'reception theory' of competence. One principle which perhaps distinguishes passively consumed services - like hairdressing - from actively consumed services like competence development ('learning') is that it may be meaningful to speak of the former as being delivered, while in the latter it seems more appropriate to suggest that whoever *seizes* the service from the flow of interaction determines finally what the content of the service is.

More than one participant - including a 'supplier' - may seize more than one kind of benefit from the performing of a service. In terms of the earlier metaphor we should now say: You can take a horse to water - and have a refreshing bath yourself! For example, a service supplier may afford systematic opportunities for learning (reconfigured competence) via its offered services ('positioned' pre-configured assets, resources and staffing). But a client organisation need not learn, and will not learn (change its competences) if it does not mobilise complementary competences available within itself. On the other hand, a supplier of a rented competence may upgrade or transform that competence (and thus learn), even while a client simply 'channels' the output in ways that do not transform its own competences.

Distinguishing between the service offered by a supplier and the service 'seized' by a participant in a service interaction helps in identifying the complementary competences that must be mobilised by a user in order that the outcomes of a given service delivery may be translated into a significant competence for them. Otherwise there is danger that a service will merely deliver degenerate forms: additions to the assets register (instead of mobilised resources), ad hoc pieces of individual learning (instead of shared stories and ways of reasoning), or isolated practices which do not have significance for the organisation.

It should be noted that an economy of competence-supply is not equivalent to a 'learning' economy. Receiving the use of a (supplier) competence on a rental basis - for example, to generate a component design - may be quite enough to satisfy the client firm's needs in its competitive situation (for example, rapid time to market with a viable product design) without any need further to 'learn' (change its embedded competences). Rather than learning, the client outcome of a competence-supply activity may simply be *action*, appropriate action, operational action: the delivery of an output by the client. As long as the action that is achieved through the mobilisation of the supplier's competences is appropriate in the client's business context (that is, competent) the service can be said to be relevant. What is at issue here is simply that we should mark the difference between competence supply, innovation and learning. Competence supply services are not necessarily innovation services and do not necessarily generate innovations in the client firm. They may be operational services, but performed by mobilising substantial competences rented from a supplier.

3.3c Competences as offered products

Competences do not only support (manufactured) products. In the service economy competences may themselves be (service) products; competence development may *be* product development. That is, a supplier's competences at the close of a service delivery may be adopted as an offered product, a prior configuration of assets, resources and staffing which may be brought to the front office on the next occasion and presented to a client in a real time delivery-performance. Thus the relationship between products and competences may be reversed in service-led business, compared with the 'strategic core competence' model proposed for R&D-intensive manufacturing by Prahalad and Hamel (1990). Strategic core competences (service products) may be supported by core (manufactured) products rather than the other way round.

Our cases underline the fact that the 'same' innovation function - for example, prototyping, testing, product development - may be presented in quite different product forms (service packages) depending on the client's cluster context. The material characteristics of the client's products, the dynamics of the value-chain system in which a client participates, and the location and strategic orientation of the client firm in its particular value chains, determine important characteristics of the innovation process (as a strategic process) for a client at a particular conjuncture. The contribution of innovation services suppliers for the 'same' innovation function thus differs between cluster contexts, regarding the kind of contribution that they can helpfully offer in terms of dynamics, risk management and other kinds of in-context facilitation of the client's competitive strategy. A service involving 'the same' innovation function can be expected, therefore, to be quite differently formulated and have different kinds of effects in different cluster settings; this applies also to actors differently located in the same cluster (for example, a small 2nd-tier component supplier or a large head-of-chain transnational manufacturing firm). Box 5 sketches some examples taken from our case studies. Appendix 6 to the present report explores the example of prototyping in two cluster contexts: auto components manufacturing and innovation of new biomolecules.

Box 5 The 'same' function presented as different service products

An R&D service for a firm that innovates biomolecules to be used in laboratory analytical processes in the pharmaceutical sector will not need the same content and presentation as an R&D service for a firm manufacturing yoghurt to sell to domestic consumers via national grocery chains, or a company that publishes books. The strong basis of this difference is not so much the chemistry of yoghurts and reagents (and certainly not the physics of books!) but the nature of the value-production process in the two clusters, and the location and positioning of the client firm within the value-

adding process. As a strategic locus for R&D in the book publishing value chain the 'chemistry' of the publisher's downstream relationship with readers and distributors, for example, is on a par with upstream research in the practical physics of putting marks on paper in digital printing. As it happens (as documented in our UK book publishing cluster study) the marks-on-paper R&D service is carried out as part of product development by R&D intensive capital goods suppliers rather than RTOs, and the market/value-chain R&D is carried out by consultants in electronic publishing (who may operate within RTOs but are more likely to be found in commercial suppliers of workflow software). A similar distribution of R&D support services - tacit and explicit - for different stretches of the value chain occurs in food manufacture (our Norwegian cluster study).

3.3d Service content

In analysing the content of innovation services (or rather, competence-supply services) the aim has been to explore the significance of explicitly delivered innovation services: How may a big or significant effect - a strategic outcome - be generated via an activity which by definition, as a service, must in some sense be small or limited, relative to the whole span of activity subtended by the 'user' of the service? We have answered this in terms of the *scope and scale of service interactions*, and the scope and scale, *downstream of service performances*, of memory deposits and ripples generated in the performing of the interaction.

3.3e Scope of the offered service, and complementary competences of the client

Competences may not be supplied 'whole'. Rather, factors may be supplied that may be organised into competences downstream of the service delivery, by being combined with other assets and competences of the client firm. The factors may be assets (such as machinery or patents) or skills, or even pieces of public property such as items of scientific knowledge from the research literature. The emphasis then shifts to the complementary assets, and complementary competences, of the user firm, which may or may not be sufficient to transform the supplied elements into significant competences. This model implies three basic options in the scope of a competence-supplying service. Table 5 shows these in order of increasing scope. The model is based on the basic categories of the competence model represented in Figure 5 above.

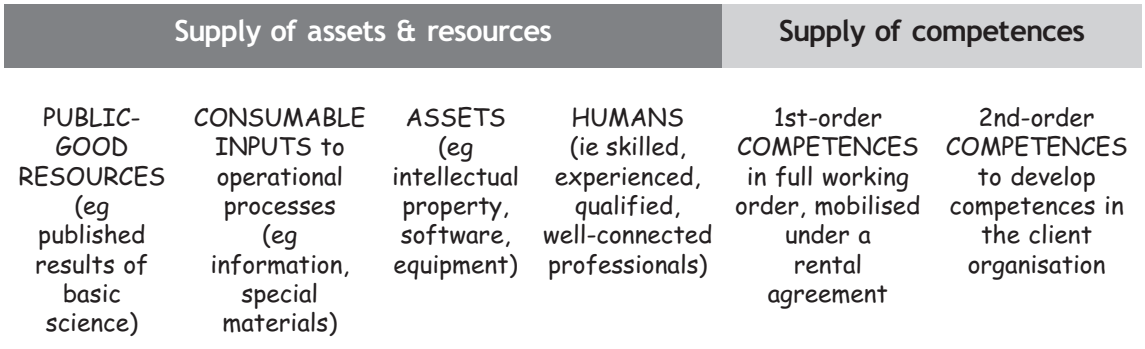
Table 5 **Three options in the scope of service content supplied**

- Supplier furnishes assets - as distinct from competences. Subsequent to the delivery of these assets (or production of these assets in situ) they may later be configured into competences by the dynamic capabilities of the recipient firm. This is a *provisioning or support* mode of competence supply.
- Supplier furnishes competences that already exist as established and probably routine abilities to do something (in the supplier organisation) based on prior configurations of assets. This is the *rental or hire* mode of competence supply.
- Supplier furnishes competences to change the competences of the client (dynamic capabilities, second-order competences, of the supplier). This is a *building* mode of competence supply.

However, an analysis based on assets alone (without paying attention to the introduction and production of resources) cannot cover sufficient aspects of knowledge-intensive service supply. On the basis of our cases the three pure asset/competence modes of supply in Table 5 have been

augmented with three dirtier, and more resource-oriented categories, to give us a six-channel model for the scope of competence supply. This is diagrammed in Figure 6.

Figure 6 **The scope of competence supply - A spectrum of stickiness in knowledge intensive inputs**



This diagram ranges its elements in increasing degree of 'stickiness' from left to right. The least sticky elements on the left are available perhaps cheaply and certainly easily: through searches of public information spaces, through spot-contracts or simple service-level contracts, etc. Assets too are available relatively simply, as a matter of routine or context-specific negotiation (spot contracts, fee-for-service agreements, licences, etc). They are more sticky than consumable inputs though; this is part of the reason that they have the status of assets and not simply consumables - it is intended that they should stay around and have an effect, and also, that they should in some way be distinct from inputs that are easily available to competitors. Humans are extremely mobile in a certain sense; but as effective participants in competent organisations they need to be regarded as sticky. By definition, competences are the most sticky things that we might try to acquire or supply; they comprise intimately woven configurations of assets, resources and humans, on a small or large scale. They are practices in full working order, and as such are not simply 'shippable'.

For the customer, the cost implications of each kind of supply (or any mix of differently 'sticky' elements) are different; which is to say, the competence implications are different. By definition, an asset- or resource-supply service demands complementary competences (including, but not reducing to, complementary assets) before it can constitute a competence in the client firm. In the case of direct supply of existing competences in full working order the cost logic is different. Mobilisation of a competence is guaranteed. But it must be located, as a live flow of actions, appropriately within the frame of existing competences and activities of the client - either as 'a piece of jigsaw' (in the case of a rented, first-order competence within an unchanged terrain of client competences) or an 'inflecting' process in the case of a competence-building service. At some level, the client depends on its own competences in locating external competences in relation to its own, and in articulating them with the ongoing flow of activity in the organisation in order to avoid compromised or lost competences and unnecessary costs elsewhere (in the case of a poorly matched or poorly integrated rental service) or a shortfall in the hoped-for outcomes (in the case of a competence-building service).

3.3f Scale of a service interaction - Services vs collaborations

One conclusion from our case study analysis is that the evolution of significant competences may be only weakly related to the delivery of explicit services. Collaborations (more tacit, more durable, larger in scope or scale, more mutual) as distinct from explicit services may be the essential way in which competences are got.

Putting this another way, in structuring the processes through which significant competences are developed it may be important to have forms of interaction which are in some ways 'bigger' and sometimes also more informal than is normally expected from explicit, discretely received services. It is a priori unlikely that a big (strategic, weighty, durable, etc) competences will be supplied by a small (discrete, limited, economical, etc) service. Our cases include examples of: strategic competences being developed through prolonged collaborations in which the only explicit, contracted services were for routine leasing of equipment (an innovative book printer, collaborating with a digital print equipment manufacturer); strategic products being developed through prolonged, evolutionary in-house R&D in which external services took only a 'tactical' role (an auto gearbox manufacturer innovating a radical new gearbox design); and a four-year programme of collaborative R&D involving four RTOs with a small firm funded under a government programme (identifying biomedical products and diagnostic technologies with good medical and commercial potential). None of these cases represents a simple supplier-to-client service.

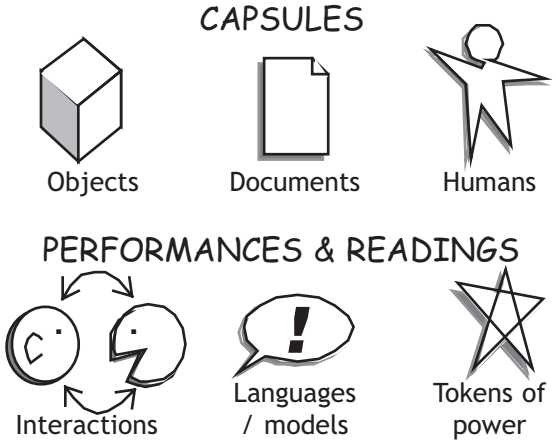
Suppliers of competences may not be explicitly selling innovation services; this is a second conclusion. The basic point here is that categories are not watertight. 'Operational' services like the rental of fermentation capacity for biomolecules may possibly be appropriated as 'innovation' services (not only because small scale is available but also because explicit development services such as recipe-optimisation may be available, along with the utilisation of production capacity). Operational services like equipment leasing may be accompanied, at the supplier's discretion, by the informal supply of an innovation service like software development. We deal with this category issue in RISE by recognising that innovation services may be tacit or informal as well as explicit, and may be provided as part of the business mix by suppliers whose majority business (in terms of profit and marketing orientation) is production rather than development. This helps in refocusing the lens of 'innovation' services in the context of a service economy. It may be helpful to consider that all forms of 'knowledge intensive' production - and not just so-called service production but manufacturing production too - may potentially be viewed as sources of competence, and thus as furnishing tacit or 'bundled' innovation services.

3.3g Scope of service received

As part of the resource perspective, RISE analyses the presentation of a knowledge intensive service in terms of six categories that define the elements of a 'presentation mix'. These are diagrammed in Figure 7.

The scale of a service outcome is analysed in terms of the downstream 'reach' of what was delivered - ie, the extent and significance of the 'ripples' in an organisation's behaviour that involve elements of the delivered output of the service. This amounts to an analysis in terms of *organisational memory*. Within the competence framework in RISE, the two basic dimensions of presentation mix (Figure 7) provide a basis for mapping the 'deposits' created in service interactions that constitute organisational memory. Each basic dimension has three subdivisions:

Figure 7 **The presentation mix of activities - Forms in which traces of action can be deposited in practices**



- Memory constituted by material 'capsules' that have been constructed or delivered during the performance of the service, which are durable beyond the close of the service event and which have been embedded in the practice of the client organisation. These may be: material objects (eg machines); documents (including software); and human bodies (eg relocated people).
- Memory constituted by elements in organisational practice that are 'performed' and 'read', which have been constructed and articulated during the performance of the service and endure beyond the close. These may be: dialogues and patterns of interaction within communities of practice; 'language games' (ie ways of seeing, thinking, speaking and interacting which are rooted in formal or informal codes that are shared and mutually recognised by qualified participants); and tokens of power (ie identifications, allocations and valuations of resources that operate by convention as distinct from simple physical access - for example, budgets, access rights, property rights, authorities, privileges).

To augment this model of memory 'materials' we have adopted a model of knowledge and knowing offered by Cook and Seely Brown (1999) which helps to identify more precisely those forms that lie in the 'performed and read' dimension. The model distinguishes on one hand between difference extents of the 'knowledgeable body' involved in the performance of knowing:

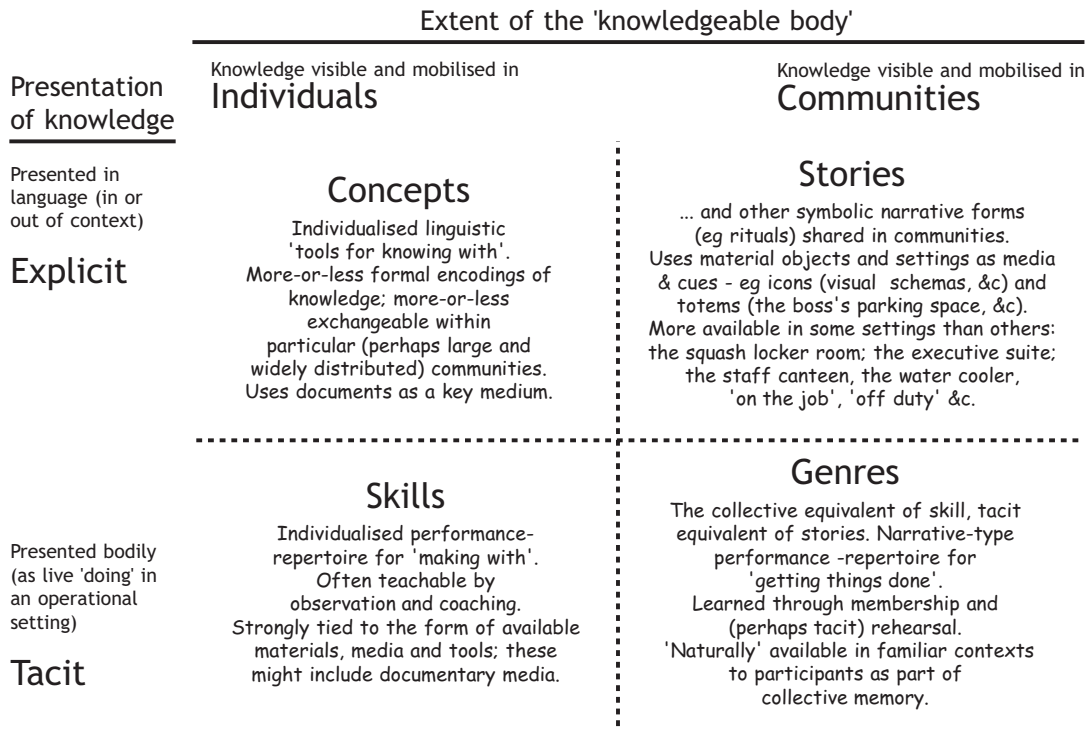
- Knowing by individuals (ie knowledges that may be exercised and displayed by individuals acting alone, with appropriate materials and tools); versus
- Knowledges that are exercised and displayed in, and constituted by, the actions of communities or groups.

On the other hand the model distinguishes between two forms of presentation:

- Knowledges explicitly articulated in language; and
- Knowledges practically articulated in action (tacit).

This classification generates four categories of knowledge/knowing: *concepts, skills, stories and genres*. These are represented in Figure 8:

Figure 8 **A classification of forms of presentation of knowledge - Knowing in practice**



Source: Based on Cook and Seely Brown (1999)

The downstream memory from services may be differently distributed across different kinds of deposits (layers) as identified in Box 6. Two of the categories in the table - genres and stories - are derived from the four-mode schema of Figure 8.□□

Box 6 **Various layers of organisational memory**

- ***Genre memory****: collective ways of behaving, ie the 'do-able', systemic behaviours of specific configurations of physical and documentary assets, specific humans, language games, patterns of interaction within communities of practice, tokens of power. This should be seen as the basic, robust and powerful form of memory: communities of practice 'in full working order'.*

- ***Story memory****: an important component of the visible, explicitly workable-with 'above water' part of the genre 'iceberg'. Shared, available, coded ways of referring to: 'what exists', 'how it all started and will continue', 'what we did', 'what we are now doing', 'what we do it with', 'what we may do', 'what will be different', 'what will be the same'; and so on. Stories are vital resources in innovating (deliberately changing the actions, asset-configurations, trajectories, etc of organisations). They furnish basic means of mapping, navigating and coordinating in complex, always ongoing, shifting environments.*

- ***Asset memory****: another important layer of the visible, explicitly workable-with deposits generated by a service. Comprises objects and documents that are valued. Thus, not just 'bare stuff' but pieces of stuff that have been invested with significance as tokens of power - assets, things worth having because something can be done with them, things that are flexible (because they can be handled, managed, moved around and separated out; ultimately, traded) and powerful in a different way when they are no longer flexible, but fixed (invested, assigned, owned, 'sunk', etc).*

Several of the RISE cases show significant components of asset memory: IT systems installations, production recipes for biomolecules, jigs and tools for mass production, portable software suites and databases. The downstream reach of such services is extensive. At one level, the assets themselves are durable and continue to constitute the core of *operational* competences in the firm for future years. But at a meta level, some of the competences generated in the client firms in these projects enabled *strategic* actions - decisions to make large-scale investments in technology roll-out at other locations in the firm. These competences themselves are only short-lived: arguably they last for just as long as the strategic decision takes. But such decisions greatly enlarged the scale of assets configured in the downstream 'ripple' of the service. Also, arguably, they changed the trajectory of the client firm as a result of the changed behaviours that these systems enabled (improved service- or product-quality) when the new competences were translated to the scale of the whole business rather than just a single operating unit that was involved as a participant in the service interaction.

On the basis of our cases we suggest that stories, in particular, may make important contributions as strategic or tactical outcomes of innovation services. On one hand, stories are resources for organising the actions of firms. 'Strategy stories' - such as those influencing the decisions in the process innovation cases referred to above - may decisively inflect the trajectory of a firm; 'operational stories' help to cement changed working practices. On the other hand, stories contribute to products. They form part of the *resource positioning* of products (as distinct from the more familiar strategic concept of asset positioning). This is perhaps especially applicable in the case of service products - which are delivered to clients as unfolding performances - and intellectual property assets, which are delivered as 'promises'. The pitch, the USP, the rationale for participation, is an intrinsic part of a product; and pitches are (hopefully well-founded) stories. Innovation in brands is an important mode, and a brand is part-story, part-asset configuration, part-artefact. We might also say that a brand is a competence. This is an extension of what was said earlier: it is quite possible, in a service economy, for a competence to *be* a product, and for stories to be important as elements in the resource positioning and execution of a product.

3.3h Scale of downstream 'ripples'

The scale of downstream effects of a service depends partly on the durability of the deposits. We have touched on this above with reference to 'asset memory'. Genre memory is similarly durable (genres include configurations of assets). Scale depends also on the extent of the deposit: a distribution of assets (for example, an ICT infrastructure for a range of activities) or a widely distributed competence has a different scale from an isolated asset or genre (located within a single workgroup or business unit, for example). However, even short-lived deposits present in practices of limited scale (eg the senior management group of a firm) may have large scale effects, as indicated above with reference to strategy stories. It is helpful here to distinguish between first- and second-order competences, as outcomes of competence-supply activities.

A first-order competence is a competence to *do* something, for example, design a certain kind of component, manufacture or test a certain kind of material or derive a certain kind of information. First-order competences as outcomes of a service may be durable (when embodied in durable forms such as equipment or stable commitments of financial assets or staff), large in scale (if diffused through many relevant sectors of activity in the firm such as different divisions or sites) and strategic - for example, the competence to quickly diagnose and fix photocopiers in customers' workplaces, in a photocopier leasing firm. First-order competences include such

important characteristics as the core production capabilities of a firm, specific productionised core products, and operational routines involved in innovation (eg testing or prototype building in an R&D department, isolation of compounds on lab scale, searching in the patent literature). Clearly, first-order does not equate to insignificant. However, the effects of second-order competences have an intrinsically different scale. A second order competence - a 'dynamic capability' - is a competence that changes competences: the asset stock and asset configurations, resources and resource distributions, the ways people work, the work that things are able to do. It is a competence in learning, if learning is interpreted in a material-systemic sense, to mean changes in the repertoire of behaviours available from a system of assets, resources and humans.

The synthesis report for workpackage 5 provides further analysis and examples derived from our case studies.

Chapter 4 Policy learning and RTOs

4.1 Briefing for the Minister of Innovation

We open this chapter with a document that illustrates the application of RISE findings in a policy context. It has been obtained by RISE from the Ministry of Innovation in one of the lesser-known participating countries, Praxia.

A core aim of RISE is to contribute to further development in the competences of communities of policy practice that deal with innovation systems and innovation services. However there have not been many studies of learning in policy-making institutions which would provide guidance for the presentation of results from a project like this. Within RISE we have done some preliminary studies of learning in ministries, directorates, research councils and other relevant institutions, interpreted as competence development. On this basis we have constructed a memo to a fictitious 'Minister of Innovation' in the face of impending further cuts in the public funding of R&D and innovation support (a persistent situation), briefing her/him on the basis of a policy for innovation services which is consistent with the RISE programme and its findings. The brief discusses:

2 Market failure and other rationales for government action
3 The 'innovation systems' framework for policy rationale
4 Competence and learning as the pivot of 'innovation systems' policy
5 Institutional failure as a category complementary to market failure; and
6 Various systemic policy measures related to the dynamics of an economy of innovation services.

A rationale for this document is presented in Appendix 8: *The Praxia memo - A didactic experiment*.

Policy Memorandum

Ministry of Innovation

Department of Innovation Services

MEMO

The Annual Cabinet Budget Conference: On the role of research and technology services in the innovation system

To the Minister,

We refer to Cabinet meeting document No. 2001-27, containing the Ministry of Finance's budget proposals in the area of knowledge production and dissemination. This Memo contains arguments that might be used in the Cabinet discussions.

1 Proposals of the Ministry of Finance

Budget cuts proposed by the Ministry of Finance

As expected the Ministry is proposing substantial cuts in the public funding of R&D and innovation support, arguing that the economy is overheating and that there is a need to curb public spending. The Minister of Finance maintains that a further increase in the inflation rate will harm the competitiveness of our industry, which in the long run may lead to higher unemployment and social unrest.

The Minister also claims that the beneficial effects of the Government's innovation policies have not been documented, and that competence building and knowledge acquisition and dissemination for competitiveness is a task for industry itself.

The Department of Innovation Services has reason to believe that the Ministry of Finance assumes that a further increase in public spending on health, pensions and social services is unavoidable of political reasons. The Minister of Finance will therefore fight hard to reduce expenses in other parts of the budget.

The Department suggests that the Minister co-operate with the Minister of Education on the topic of funding of basic university and college science (see separate Memo on the overall R&D budget).

This Memo will concentrate on the issue of producing, distributing and upgrading competences in the innovation system.

2 Market Failure

The Minister of Finance will accept that there is a need for public support for research and development. She will do so on the basis of the traditional market failure rationale. The argument goes like this:

The Market failure argument

R&D that leads to new or improved products, processes or services will not only benefit the company that perform or finance this activity. The companies and people that use this new product will also profit from increased efficiency. A new drug will not only benefit the pharmaceutical company, it may benefit the

whole society.

According to the market failure argument, firms are prone to invest too little in R&D, as they are unable to harvest the profits following from this *spin off effect*. This is a problem if the competitors benefit as much from the innovation as themselves. Moreover, R&D is always a risky adventure, which may stop some firms from investing.

Although this department is sceptical towards some of the premises behind the concept of market failure (especially the idea that the chaotic nature of everyday business is but a deviation from 'perfect' or 'balanced' market conditions), there is no need to argue against it. It is certainly true that society at large may benefit much more from an innovation than the company doing or financing the research. This is a strong argument for public support for R&D.

3 The systemic view of innovation

Traditionally economists have tended to view innovation – i.e. the learning-based process of developing new, and improving existent, products, processes and services – as something that is introduced into the economy from the outside ('an externality'). Although most – if not all – economists now agree that technological development is a major contributor to economic growth, innovation policies are normally not considered a part of economic and financial policies.

Modern innovation theory argues that:[1]

Innovation is an integrated part of the economy

Technological change cannot be seen as something delivered from the outside into the economy. Innovation is rather seen as an integrated part of economic development. Managers, workers, engineers and researchers all take part in a process aimed at producing and developing products that someone asks for or might need in the future. The most successful firms are most likely those that manage to advance new or improved commodities or services.

Companies take part in clusters

No company is an island in itself. All firms take part in complex networks of suppliers, customers, partners, consultants and research institutions, as well as various forms of public governance and regulations.

Studies show that companies are more likely to interact with some companies and institutions than others, i.e. with those they share a common interest. It turns out that most companies have the closest relationships with customers and suppliers within the same branch of industry or the same field of trade.

If you map the flow of trade, people and knowledge between companies, you will find clusters of companies that are strongly inter-connected, often being suppliers and buyers in the same chain of production. These companies frequently interact with the same parts of the public apparatus, including research institutions, offices and programmes that are established to help these companies with advice, information, facilitation and money. You will also find privately owned consultancies (knowledge-intensive business services) that aim at supporting these firms in their innovation effort.

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[1] For a general introduction to modern innovation theory, see the RISE literature review or *Innovation policy in a knowledge-based economy*, European Commission, Luxembourg 2000.

Groups of firms and institutions may be anchored regionally or locally, in which case we talk of *regional or local clusters*. Patterns of interaction might also cross regional or national borders, forming *national* or *international clusters.*

Industrial success rests on an efficient supply of competences

It follows from this that the economic success of an industry to a large extent rests on the distributions and flows of competence-building resources in the relevant clusters, i.e. on whether the individual companies are able to get hold of, understand and use the resources available in the cluster. These resources may be found in various institutions, and includes formalised, research-based knowledge.

In a similar vein one could argue that *in the long term* the main key to the economic health of a nation is found in the production and reproduction of relevant competences and knowledge in the innovation system, not primarily in interest rates, inflation rates or a balanced budget.

The RISE project indicates that as long as clusters have built in mechanisms to renew and re-invent themselves their competences and experience are very precious assets, regardless of their R&D-intensity (i.e. whether they are classified as 'high-tech' or 'low-tech'). However, most successful clusters are the results of long and complex social processes. To artificially create new cluster may be a too costly strategy from both a policy and industry point of view. It is much easier and cost-effective to build on existing strengths.

When developing their competences and innovative capability firms may interact with various forms of competence providers, including other firms, public institutions, universities and colleges. From the firm's point of view these all provide competence *services*.

Some companies and institutions specialise in providing *research and technology services* for firms. These have traditionally been called RTOs (Public or semi-public *Research and technology organisations* – including laboratories and research institutes) and KIBS firms (*Knowledge intensive business services* – predominantly private consultancies).

The EC RISE study shows that in quite a number of clusters RTOs and increasingly KIBS firms provide all sorts of knowledge-related service functions that help actors in this cluster to innovate and to adapt. The mix of service functions and the balance between what services are provided by RTOs vs. KIBS firms' vary from cluster to cluster. However, the general trend is that RTOs tend to move more downstream providing more hands on and implementation like services, whereas KIBS firms increasingly perform services that used to be associated with RTOs and institutions of higher education only.

4 Competence and learning

Innovation depends on the ability to learn

Modern innovation theory argues that the companies' ability to innovate rests on their ability to learn. By this is meant not only learning through trial and error within the companies' own walls, but by learning from others in the system of innovation.

Learning is not the passive absorption of information. Information is in itself worth nothing unless you know where to find it, and how to mobilise it in a

relevant context – hence the need for close interaction with other people and institutions.
In order to learn and stay up to date the companies and their employees must stay in touch with related companies, institutions, and other sources of knowledge and competence building (including everything from research laboratories to trade fairs, conferences and professional associations).

Knowledge is not a 'free' or common good

The Minister of Finance may argue that knowledge is a common good – freely available to anyone who knows how to read. In practice, however, it is not. In firms knowledge is but an aspect of competence, meaning the ability to perform significant tasks and to solve problems that enable firms to compete effectively and sustainably in markets. Abstract theoretical knowledge is of small value unless it is utilised in innovation *practice*. Another company cannot just download a competitor's organisation or work and life experience from the Internet.

This is why companies invest in R&D in spite of the market failure, and this is why companies adopt innovative practices and organisational structures. For a period of time they will have competitive advantage based on improved competence that may be hard to imitate, even if they are unable to patent the innovation.

Tacit knowledge

Knowledge includes so-called 'tacit knowledge', including the contacts of individuals, intuition and creativity, social intelligence, background knowledge, a sense of context and appropriateness, and more.

Culture and social skills

At the collective level, knowing 'what to do' in a firm involves company and business culture, shared 'genres' of practice, and the local languages and stories that are 'part of the furniture' of a workplace. Competences – a firm's abilities to do significant things in markets – include such tacit as well as explicit and formal elements.

Machinery

Competences also include the material apparatus of the firm – concrete configurations of capital assets such as machinery or computers, materials, documents, the communications infrastructure, the physical and practical organisation of space, etc. In practice, the competences of a company take the form of the entire organisation of resources available to actors in the firm.

Tradeable assets

Consequently learning is related to the acquisition of assets, including tradable knowledge assets, the 'public goods' of basic science and 'hard' technology and machinery. But tradable assets and public goods are not, in themselves, competences. Further investment is required to 'configure ' them into significant competences – to make them useful.

Whether a firm succeeds in developing the much-needed competences, depends to a large degree on its ability to build linkages to relevant firms, organisations and research and technology services. Although a firm can be said to belong to a certain 'industry cluster' (which is a theoretical concept), that does not necessarily mean it is good at 'networking'.

5 Institutional failure

The Minister of Finance would like to cut the budget of several programmes targeting competence building in firms and knowledge dissemination, claiming that this is the responsibility of industry. She claims that the public's responsibility should be limited to funding university and college science.

Lack of networking and the ability to find, understand and use new knowledge

However, recent research from the EU research project RISE and others confirm the need for such programmes. A lot of companies lack the competences - as distinct from the finance - needed to make use of university science in specific competitive settings. The staff may not have the education that is needed, they may lack the necessary contacts in the university sector or they may lack the experience of transforming academic knowledge into industrial competences.

As it happens, most innovation is done without *direct* use of university research.[2] For most companies it is more important to build learning relationships with other firms, suppliers as well as customers.

Moreover, they may also lack the experience to evaluate how relationships with external sources of knowledge, skill, assets and insights might contribute in a practical way to new, improved, relevant competences.

Systemic failure: Blockages in the knowledge flows

Companies thus often face what researchers have called *systemic failure*, i.e. they are unable to recognise or mobilise resources needed to perform certain innovation activities. They cannot get access to a relevant competence (from an external specialist) or the means of building a relevant competence within the firm. One could say that flows of knowledge and other competence resources in the innovation system are restricted in such a way that it hinders much needed innovation. This is especially true for small and medium-sized firms that often lack the personnel and competences needed to access the relevant networks and institutions.

Issues of perception are involved, together with interpretation ('making sense' of unfamiliar arrangements), communication, practical abilities to get certain things done, finding the right institutions etc., which make them invisible to potential beneficiaries.

Real time, real space - no perfect market

In a sense these are all 'market failures'. A perfect market would have none of these problems because all information would be perfectly meaningful and all resources perfectly available. But in real-time and real space, real humans and real firms have these problems of institutional failure. 'Hard' institutional failures are in formal organisations (e.g. the structures and boundaries of universities, government departments, firms), 'soft' failures are in culture: good practice, norms, language, expectations, stereotypes, etc.

The market does not guarantee

Some policy makers argue that the impressive growth of the KIBS market, shows that the private technology services do meet the demand of industry and that

[2] Meaning that they are not using results from basic research directly and that they are not in contact with universities and other institutions doing basic research. However, they may use knowledge and technologies, which have components that have been developed through basic research. For instance: All companies use computers, and although modern computers are not developed in science labs, they contain materials developed through basic science and software based on logical systems developed in universities.

strategically positioned service suppliers

there for this reason is no need for public measures. However, the RISE programme has documented that research and technology services may be marginal in particular clusters of innovating firms, while simultaneously being viable as revenue-generating companies. In other words, the market in research and technology services does not guarantee that the companies that need them most use these services, or that the services offered are the (perhaps risky) ones of most strategic benefit to a cluster.

6 Systemic policy measures

Public support for developing a network of research and technology services

This is why the Ministry of Innovation has decided to support the development of so-called *research and technology services*. These are services provided by firms, institutions, organisations or programmes that help firms get access to much needed competences in these external organisations, or to factors that enable them to build and upgrade sustainable competences in-house, as well as exploiting the existing assets, resources and competences of the firm.

The Ministry of Finance will probably argue that the public contribution to research and technology services should be the responsibility of public universities, colleges, R&D institutes and laboratories only. These do indeed play important roles as such service providers.

However, the Minister could argue that institutions like the universities and colleges have tasks that go far beyond the needs of industry. Their role of providers of basic, long-term science often demands a culture that is not always compatible with the short-term horizon of small and medium-sized businesses. A too strong focus on industry needs may undermine the long-term aspect of university research. Furthermore, what the firms need is often not new basic science, but more practical technological or organisational solutions based on already existing knowledge.

RTOs and KIBS firms

The main business oriented competence services today are the research and technology organisations (RTOs, mainly industry-oriented, public-funded technology institutes or research laboratories) and knowledge intensive business services firms (KIBS, including various forms of private consultants and professional services firms). Under pressure of reduced public funding many RTOs increasingly operate as KIBS firms, perhaps on a private non-profit basis.

The recent RISE study shows that RTOs are so diverse in their institutional form and service activities that it is impossible to give a clear definition, and misleading even to offer a typology. From an *innovation policy* and *functional* point of view it is probably better to talk about research institutes, laboratories, consultancies as *research and technology services*. To these services one should also add units performing routine operations associated with the productive use of technological apparatus – for example, testing and certification, maintenance, health and safety audits – and providers of machinery and new technology. These may not all be targeting innovation directly, but by contributing to the competences of the firm under the guidance of the firm's own strategies and high level competences ('dynamic capabilities') they strengthen the firm’s ability to innovate.

It should be added that from an institutional and administrative point of view, it may still make sense to speak about R&D institutes, RTO, KIBS companies, etc.

Some research and technology services do an excellent job connecting firms with firms, firms with R&D institutions, and firms with relevant public measures, but the effect of their work varies from region to region, industry to industry. This variation is partly due to individual, cultural and historical differences in the institutions, but mainly due to the differing dynamics and requirements of the clusters served by the RTOs and KIBS firms.

Of course, innovation systems and clusters are dynamic, i.e. they change over time, and the relevance or effectiveness of public-funded RTOs, for example, may change (especially if RTOs or universities themselves do not change).

The innovation system is varied and constantly changing, hence the need for dynamic innovation policies

This variation means that one cannot base innovation policy on a theoretical basis that treats all firms, industries, regions and research and technology services in the same way. This is why the Ministry of Finance is mistaken when they claim that there is no need for public measures in this field. The individual business owner cannot – and probably should not – concern herself with the overall functioning of the innovation system. It is her job to develop a successful firm where she is. The same applies to managers of RTOs; they have a difficult job maintaining the excellence of their services, balancing the budget and identifying appropriate, competent clients for their services.

The public institutions have the overall responsibility for developing the innovation system

On the other hand, the public policy makers, the industrial corporations and relevant researchers should be able to develop an overall view of the national and regional innovation systems, including the public and private research and technology services provided within them.

The public sector may contribute to the development of a comprehensive system of knowledge institutions and innovation programmes that can improve the flow and distribution of relevant competences and competence factors in various industries and clusters.

Private KIBS companies will always play an important role as competence suppliers for firms, but they are not able to fulfil the needs of the whole system. There will also be a need for publicly organised and funded policy vectors.

The RISE programme (Final report, Section 4.5) identifies ten core elements for policy related to research and technology services (RTOs as well as KIBS firms):

- Adopt a perspective of a hybrid public/private economy of research & technology services (R&T services). RTOs form part of a broad 'manifold' of tacit and explicit services covering both innovation and operational needs of firms relating to technology and systematic knowledge.
- Adopt a service economy perspective, rather than a perspective based on R&D for manufacturing. Service innovations are very significant in all sectors. Intermediate services are important in technology transfer and policy delivery.
- Build firms' competences to use external research and technology services In most advanced countries, articulating demand is more important than increasing the supply of research and technology services.

- Facilitate a sound division of labour in the R&T services economy, between various kinds of suppliers and different kinds of service content. Use a full, integrated repertoire of government roles, including purchaser and developer/franchiser of new services, as well as funder, regulator and standards agency.
- Match services to cluster requirements in strategically important clusters ('high-tech' as well as 'low tech', new as well as traditional industries).
- Facilitate and fund collaborative R&D in supply chains. System failures as well as market failures prevent the development of effective demand for innovation services, especially for SMEs bearing high levels of risk in global supply chains.
- Assess research and technology services' contribution in specific clusters, and give priority to existing clusters when developing public-funded or sponsored vectors/measures.
- Facilitate changes in the service modes of RTOs: towards greater intensity of routinised, 'client learning' content with firms whose technological capabilities are less highly developed, and towards services with greater 'asset transfer' transactional content.
- Identify the actual innovation functions of RTOs and other actors in the innovation system. The various institutions contain mixes of economic and social tasks or functions, which vary from cluster to cluster and from country to country. Research is needed (mapping) to support policy action.
- Safeguard multiple roles of RTOs under other aspects of policy (including employment, labour relations, the environment, health, public welfare, culture and social affairs). There may be a rationale for public funding here, even if not in connection with innovation services.

7 The innovation White Paper

Change and Opportunity

The Minister could remind the Cabinet of the recent proposals forwarded in the white paper on innovation policy *Change and Opportunity – on Industrial Innovation and Creativity*. This clearly states that the Government wants to go beyond the traditional research policy, where the State focuses on supporting R&D institutions only. The paper states that:

To establish a structure of competence institutions

> 'It is the goal of the Government to establish a well functioning institutional structure of R&D institutions, knowledge-intensive business services, public measures for high risk financial support, and programmes aimed at improving the competences of firms to learn.' (p. 17)

Dynamic capabilities of firms

> ' One should increase the dynamic capability of firms, thus strengthening their absorptive capacity and generating and updating their strategic technological competences.' (p. 18)

Uphold modern education

> 'It is the goal of the Government to uphold a modern, adaptive sector of education of high quality that may bring out skilled and creative people that can fulfil the needs of our society, our culture and our economic life.' (p. 35)

However, this is not enough. When focusing on the needs of business, the paper also focuses on the systemic nature of innovation and knowledge-creation:

Develop public research and technology services for interaction and co-operation

> 'The Government will continue to develop public services aimed at improving the interaction between the participants in the innovation system. These will include publicly funded, chartered or franchised research and technology services in areas of the economy where there are few or no relevant private companies. Where the opportunity offers, these will be 'prototypes' of potentially viable commercial services. (...)
>
> 'The main effort, however, will be targeted towards programmes for co-operation and interaction within and sometimes across various industrial clusters: 'collaborating for competition'. These measures will counteract institutional failure of both an organisational and a cultural kind within the system, failure that prevents resources and competences outside the firm from being identified or used in innovation. (...)
>
> 'Sometimes market failures of a straightforward kind are involved and appropriate financial measures (e.g. public venture capital) will be integrated with 'institutional failure' measures.' (p. 45)

Regulatory reform.

> 'The Government will continue to improve structural elements in the system, including regulatory frameworks, taxation, technical standards, risk-management rules, health and safety regulations.' (p. 46)

Programme to strengthen the learning capacities of firms.

The white paper also announces (pp. 54-60):

- The creation of a new programme aimed at supporting the building of systematic competences of firms to evaluate and use external sources of knowledge and capability,

A mix of private and public.

- The development of a service system based on a sound mix of private and public institutions, including hybrids based on public as well as private finance and participation,

Programme for strengthening the competences of policy makers.

- A new programme aimed at building in the strategic and administrative competences of policy makers involved in innovation policy and the design of research and technology services. The Government shall identify the actual innovation functions performed by public-funded suppliers and R&D services in the various industries, clusters and regions, and get a better insight into their various roles and tasks.

Some RTOs have functions going beyond the role of research and technology services, including scientific advice to the public, inputs to political debate and decision making, inputs to judicial processes, operational services to firms and government departments, or – even – basic research. The Government has been criticised for trying to sacrifice these long-term public tasks on the altar of 'short-sighted' innovation processes in industry. Some of the ministers may repeat these concerns on the conference, especially the Minister of Culture and the Minster of Health and Social Affairs.

The Minister can refer to the White Paper's discussion of these matters. It states that these functions should not be weakened, as the interaction between the various functions will strengthen their long-term ability to perform research and technology services, as well as their capability of accomplishing other tasks.

8 Conclusion

University science and industry

There now seem to be broad agreement on the need for strong support to our R&D institutions, and especially for university science and 'bridging' mechanisms between university R&D and industry such as the Foresight programme and various regional networking initiatives.

Clearly university research has cultural and social goals that go far beyond the needs of industry. From an economical point of view, however, the Government has a responsibility for making certain that relevant competences and resources developed in these institutions are utilised by industry in the most efficient way possible.

Exploiting the competences of industry

It is also important to ensure that the competences of our industry are exploited effectively, since these constitute a far larger national resource base than the whole of the university sector. This can only be done by a two-pronged strategy.

Establishing a learning framework

- Establishing a framework that improves the companies' ability to learn, mobilising, generating and using new competences.

Improving innovation linkages

- Improving the linkages between firms and between firms and institutions (including firms) that provide research and technology services in the form of either 'ready to use' competences for innovation, or various factors for competence-building (including data, information, staff, physical technology and intangible assets).

An innovative industry gives a strong economy

Our economy and our welfare rest on an industry that is able to innovate and adapt to constantly changing environments. Hence it is in the interest of both society and the Ministry of Finance to support measures that improve the competitive edge of industry.

Need for strong public institution for innovation and co-operation

In order to develop such instruments and policies, there must be room for strong public institutions and offices that have the financial resources necessary to learn the nature of the various clusters and industries, and the research and technology services that are available or relevant for these purposes. There must also be institutions that can evaluate these measures and suggest improvements.

The Ministry of Innovation must therefore oppose the proposed cuts in the research and innovation budgets, and asks that the proposals forwarded in the white paper on innovation is carried out according to plan.

END OF MEMO

4.2 Institutional change

In this section we outline the way in which RISE has dealt with issues of institutional change. This is followed by four sections which discuss:

4.2 The changed perspective that we now adopt towards the three core questions defining the aims of RISE: how to map systems of innovation, how to balance public and private activities and how to steer systems of innovation.

4.3 Some national conditions that bear on the adoption of RISE-related strategies

4.4 Policy positions emerging from the RISE findings - we identify ten principles to underpin policy action

Understanding and influencing institutional change is at the heart of the RISE agenda. RISE has not simply studied an object of policy interest 'out there' among the activities of an industrial system, so as to report on its relevance to policy actors 'over here' so that they might consider these data. It is true that dynamics exist within and between firms: the scale and diversity of markets for innovation services is increasing, and this does not simply reflect the outsourcing of activities previously conducted in-house in some innovative firms. But the research object of RISE - the changing landscape of innovation services and the changing location of RTOs as institutions on this landscape - is in fact shaped strongly by the actions of governments. The effects of the ongoing squeeze on public funding are probably the dominant ones in determining the changing activities and institutional location of RTOs. Thus the relationship between government activities - policy practice - and activities in the emerging innovation services economy is itself an object of study for RISE. Our Brief for the Minister in Section 4.1 above comes out of this strand of research. It forms part of the synthesis report from workpackage 4 (Koch & Hauknes, 2000). The present chapter draws in various ways on our research into and systematic reflection on the conditions under which analytical strategies like those we have pursued in RISE may make their practical contributions.

4.2a Institutions and functions

Our overall approach in RISE has been to focus on the functional content of services and lessen the focus on institutional characteristics of suppliers. As far as possible we wanted to escape the limitations of a 'supply-side' sectoral bias in studying innovation services. This means, for example, that we have paid less attention to KIBS firms as such, and more to the supplying of 'knowledge intensive' business services in various forms, as a contribution to what client firms are subsequently able to do (to innovate, to innovate more effectively, to compete effectively, to build and significantly transform significant competences).

As an exploration of the knowledge economy, therefore, our investigation has dealt with knowing as a strategic mode of activity that contributes to (other kinds of) significant doing in firms, rather than with institutional structures of knowledge. This is the implication of our 'function' bias: the basic question is: What does it do? But it turns out that one of our central mapping activities - the survey of innovation functions in RTOs and KIBS - gains much of its insight (perhaps the majority) from questions which at first sight might be said to address 'institutional' characteristics rather than 'functions'.

For example, as discussed in Appendix 7 (Section 7.2), in order to distinguish types of RTOs in Portugal from those in Sweden or the UK, it is useful to refer to the different mix of outputs delivered into 'public goods' domains (journal papers, trained scientists, etc) and 'client' domains (services to firms, services to government or public sector organisations). This is a reflection of the concrete positioning of specific institutions in relation to others in a national system of innovation, especially with regard to the funding of inputs (eg labour funded out of government grants or private contracts) and their allocation to outputs. In respect of their public outputs, Portugese RTOs are closer to the Swedish (and other RISE countries) than to the British; in respect of their industrial client outputs, the Swedish are closer to the UK than to the Portugese (with other countries intermediate); with respect to their government client outputs, the Swedish are closer to the Portugese than the British. On one hand we recognise these positionings as being institutional relationships between broad 'sectors' of economic life. At the same time there is a sense in which the distinctions we are talking about here are 'functional' ones. They characterise the functions that an organisation contributes, as a specific organ of a viable body-politic. However, this is different from the analytic sense of 'function' that was used within our survey of RTOs. In designing the survey we interpreted 'functions' to be phases in a standard model of an innovation process (R&D, implementation, etc: see Table 1, Appendix 7). Perhaps, in recognising this important contribution of 'institutional' analysis we have not departed from our commitment to function-based analysis, but simply begun to adopt a properly systemic, multi-lens or multi-layered interpretation of the functions that a real historical institution actually carries in the setting of an innovation system. The practical functions are defined within the context of the whole system and its other parts, as a working division of labour between 'organs'.

As a result of our research we now must acknowledge that the central defining characteristic of stereotypical RTOs as distinct from KIBS firms is not that they transfer technology or solve technical problems or do basic research or train scientists (that is, an abstracted function); it is that they are 'public'. By this we refer centrally to the fact that they receive funding from government to perform (some of) their activities. The issue of whether RTOs differ from KIBS is then an issue of whether the provision of public funding furnishes useful innovation-supporting services that are otherwise going to be absent from a specific system of innovation because no other institutional actor has the assets or resources to perform them. This is a matter of the contingent, historical positioning of specific RTOs and their outputs within a system of other institutions which absorb various combinations of inputs and perform various kinds of production, each in the context of the others. In one country it will be relevant for RTOs to perform basic research - and be funded for this via core funding or programme funding - because this furnishes a way, in that specific setting, to bridge globalised basic research with local industrial activity. In another country this will not be essential because the links are accomplished in other, historically developed ways - by universities, by large firms, by professional associations, by other government agencies, by the established practices of RTOs that do not do basic research but are able to make translations between the contexts of industry and the science base.

4.2b Institutional location

On this basis we have noted various significantly differing aspects of institutional location in different national systems and cluster systems of innovation:

- The commercialised ex-RTOs of the UK are less 'public' than the others in the scale of outputs that are not dedicated to specific institutional clients (eg, academic publications, PhDs, etc) but are nevertheless more strongly connected with government as a client. This remains so even following a cut during the 90s in the level of UK government

programme funding support that they receive and after the removal of all institutional core funding.

- Comparison of two biotechnology clusters (Portugal, Sweden) shows that RTOs with different institutional locations can be involved in different ranges of services in the 'same' cluster.
- Our hypotheses regarding the institutional trajectories of RTOs (the thesis of 'KIBSification': Appendix 7) were defined by the emerging competitive relationship between RTOs and KIBS. But it seems that the relevant complementary institutions for RTOs (strategic allies) are more often not KIBS firms but university research institutes. University research institutes also are competitors, but in the Netherlands, for example, are regarded as much more serious competitors than in the UK.
- Networks of service providers and alliances between RTOs are important, but can be constituted on either an ad-hoc or an institutionalised basis. Some very large RTOs contain many strategic business units, each of which may be regarded as a mini-RTO (and in a survey should form the unit of analysis). In other settings federations and networks of RTOs exist but they may be created by statute and charter (as with the German Fraunhofer system) or by negotiation and business alliance (as with the AIRTO network of independent (ex)RTOs in the UK).

On one hand such differences of institutional form and location determine, in material ways, the mix of services available from an RTO within an innovation system and the pattern of distribution of the overall service mix across various institutions (the 'manifold' of services available to a firm in an innovation system). On the other, some dynamics of the service supply system are determined by the level and form of aggregation of operating units in the system. Especially, dynamics are a function of the 'stickiness' or closeness of coupling between the operating units: units within a large corporate RTO, partners in a network or federation, actors in a market.

4.2c Governance

We find that we have gathered substantial amounts of evidence that calls for a kind of analysis RISE was not designed to provide. The term 'governance' came to the fore in the second year of our research. Developing an analysis using this kind concept calls for inputs from political science or public administration or institutional sociology, but neither of these disciplines is present in the workpackage mix of RISE.

Various phenomena can be noted, for example those in Box 7.

Box 7 Some 'governance' phenomena in RISE

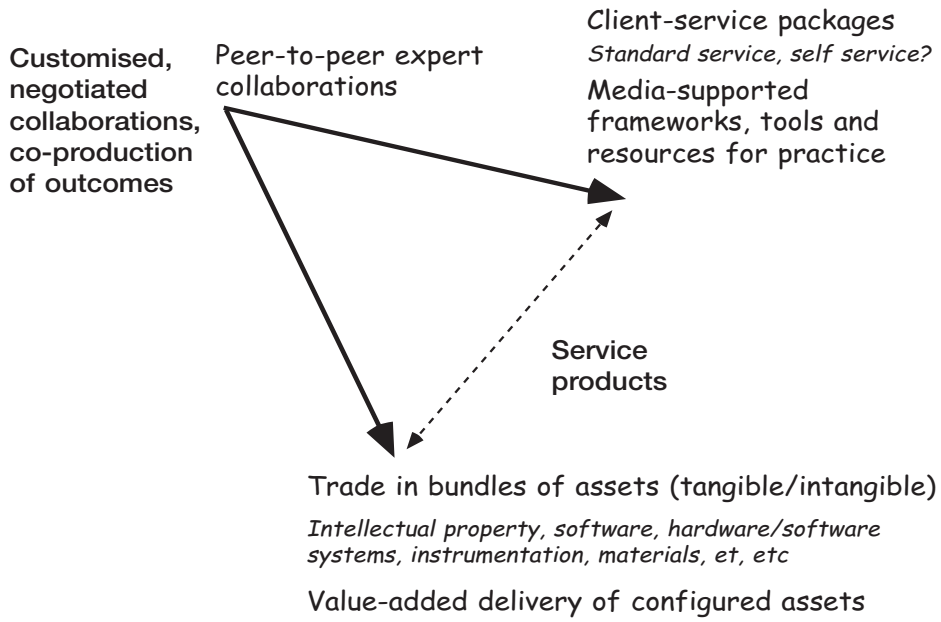
- *Membership based RTOs have been more and less popular in different countries as an institutional form. The governance of such institutions (particularly, management of the relationship between funding inputs and service outputs) differs substantially in different countries. In some it occurs in management boards of independent RTOs, where direct subscriptions are made by firms to an RTO. In others it occurs in an umbrella funding council, which levies a tax on firms in a sector and distributes funding across various relevant RTOs.*

- *The core distinction between commercialised (but not fully privatised) RTOs and KIBS firms lies in their formal character as institutions rather than the operational realities of the functions that they offer to firms or their revenue mix. For example, KIBS firms may operate substantially in public-contract markets, competing with RTOs or universities in precompetitive R&D or research-&-technology services for government clients. However, this differing institutional composition of the supplier - specifically, the funding base and the structure of the asset base accumulated under*

public funding - means that some of the service products offered by or brokered through RTOs differ from KIBS in the price/content/value-added characteristics that they present to user firms, and in the assets that may be mobilised in service provision. This can simply be because of the element of public funding (a 'bundled' financial service, in the form of distributed core funding or dedicated programme funding) that is factored into the service. The service may be 'cheap' - and either unfairly competitive or not strictly comparable with a KIBS service; it may be unique and deserving of public-good funding.

- *Increasingly frequently, governments choose to use service contracts or project contracts rather than institutional core funding as a channel for funding in research-related and innovation-related initiatives. (Appendix 1 identifies four dimensions or channels through which governments may determine trajectories of RTOs: providing funding; steering or regulating their activities more or less directly, via management structures, charters, etc; regulating, liberalising or sponsoring markets that RTOs operate in; or acting as a demanding, major customer for services.)*

Figure 9 **Two trajectories for a traditional RTO**



Reproduced from Figure 2, Appendix 7

- *RTOs may develop new products with distinctive trajectories (see Appendix 7 on asset packages and 'interpreted-resource' packages; Figure 9 above reproduced from Appendix 7). New forms of asset governance or interaction governance may be called for. The asset-package trajectory involves generating configurations of tangible or intangible assets; the rules of traditional RTOs may forbid this kind of activity. Changed guidelines rather than changes in legal articles can sometimes be enough. Otherwise it may be appropriate to separate these activities by creating an institutional boundary and applying a distinct form of governance to the new organisation and the interface (eg creating a spin-off firm with an intellectual property ownership agreement or royalty agreement). It may be possible to accommodate the governance of the new activities by structural changes within the existing institutional framework (eg by creating specialised operating units within the organisation, answerable to a different rationale and supported differently with*

> *inputs). The interpreted-resource model of activity involves configuring resources and interpretative practices (stories, images, small-scale genres of activity, schemas, etc) into routinely deliverable configurations (ie 'performances in repertory'). Such outputs typically are not rewarded by professionalised research fields, and especially, by usual academic criteria. Frameworks for suitable for evaluating and rewarding success on this kind of trajectory will typically diverge from the norms of scientific practice which often predominate in traditional RTOs.*

4.2d Hard and soft institutions

Within the above examples a distinction is needed which, in the language of innovation systems thinking is sometimes handled via concepts of 'hard' and 'soft' institutions (see the RISE literature review, chapter 3: *Economic rationales of government involvement in innovation and the supply of innovation-related services*). Hard institutions are formal organisations, determined for example by formal allocations of ownership and exploitation rights on assets. Soft institutions are durable and often informal 'cultural' realities - interpreted, negotiated or performed forms within economic and political practice, such as languages and symbol systems (including both formal and informal codes), power structures (again, both formal and tacit), forms of interaction and systems of values, shared perceptual frameworks, stereotypes or norms (including the formal norms of law and formal or informal frameworks of evaluation), and so on. Thus, in the example above, in addressing the formal organisational structure of RTOs and the arrangements applied to governance of assets when an RTO develops new product trajectories, 'cultural' issues are raised as well as issues of organisational structure. The audience for the scientific outputs of European RTOs is made up of professional peers, and the interactions and evaluation processes that are natural in this kind of institution are peer-to-peer dialogues with other members of a scientific or technical expert community. But when the outputs diverge from these norms, other kinds of 'soft' institution become called for - evaluation frameworks, professional norms, reward systems, networks of allies, landscapes of resources and assets.

In its beginnings, the RISE project started with an emphasis on (dynamic?) functional classifications of RTOs and innovation-related services, in opposition to (static?) structural sectoral and institutional classifications. However, what emerged more clearly - beginning with our literature review and continued in the second year of research - is a dialectical *practical* relationship between a static, institutional and a dynamic, functional view. 'Hard' institutions in an innovation system (actual formally constituted organisations) appear in many cases to be extremely stable: RTOs, government labs, universities, etc. But the functional content of the work they do may be quite dynamic, and it seems that their profile of actual delivered services may shift substantially over time. If this occurs, then institutional stability appears to be an advantage rather than a problem. The stable institutional 'surface' may not signify conservatism at a policy level. Rather, it may provide familiar channels of access and communication (ie a 'container' or a form of inter-institution presentation) for a dynamic mix of operational capability or content. This content shifts mostly through shifts in soft institutions that may link and transcend organisations (culture, interpreted reality) rather than hard institutions (organisational boundaries). There can be (soft) institutional change within a (hard) institution. This distinction between hard and soft institutions is a useful one, enabling 'change without apparent change' to be analysed. The same kind of work can be done within the RISE 'micro-institutional' analysis framework of competences and competence-supply interactions (workpackage 5 synthesis report: Hales (2001)) by the dual analytical frameworks of asset perspective and resource perspective.

4.2e Institutional learning, dynamics, communicative interaction

Learning in the analytical context of RISE is essentially institutional learning - the rebuilding and re-shaping of institutions, their configurations of assets and resources, and the inflection of their courses of action - as distinct from individual learning. 'Institutional' here implies:

- Collective - involving aggregates of humans and aggregates of resources
- Historical - having durable effects and an extended scale
- Practical - being demonstrated in practice by actions and not merely existing as theory.

In other words RISE adopts a 'strong' organisational learning perspective: organisations 'learn' and are not simply composed of individuals who carry and accumulate knowledge.

This does not rule out attention within the RISE framework to significant learning by key individuals within innovation systems, or individuals as important vectors of learning (eg in labour markets). The emphasis on institutions here should not preclude acknowledgement that the processes and structures involved are also cognitive. Meanings as well as bodies are involved in competences and infrastructures, so that communication and perception (eg the perception of significant resources, the communication of significant possibilities) are both basic to the usefulness of infrastructures and the competence of competent practitioners. In other words 'cultural institutions' form part of the perspective as well as formal institutions (formal organisations) and there should be no opposition between a cognitive and an institutional approach. This is one of the strengths of the combination of a resource and an asset perspective within the RISE concept of competences and an economics (actually, a political economy) of competence supply.

In English, and particularly for some actors in the dynamic, commercialised ex-RTO sector in the UK, 'institution' has some negative connotations. It can be taken to imply bureaucratic or traditional organisation (something that is 'institutionalised' and resistant to change). However, in our perspective the term refers to significant 'pieces of socio-cultural machinery': an established 'hard' organisation (like an RTO or a government lab) or a soft 'way of doing things' that is durable and has a wide reach into various spheres of activity in dispersed locations on different occasions. For example: a programme/funding format in a government funding agency, a service product in a KIBS firm or a peer-group evaluation framework for scientific activity within RTOs and universities. In either sense, hard and soft institutions are powerful (at least partly, because they are durable) and this rather than conservatism or tradition is what defines them in practice. institutions bridge locations in time or place, constitute continuity or resistance, enable and disable specific actors and actions in some significant way. Significant change requires change in (hard or soft) institutions and relationships between institutions. Significance, in turn, is determined by institutions: the basic power embodied in an institution is the interpretative and symbolic power to attribute significance and justify resource allocations, thus determining or inflecting courses of action and (institutional) trajectories. As paths or locations of power, institutions are the very stuff of government, management, administration and strategy.

4.2f Institutional change in RTOs

RTOs have seen (in varying degrees in different countries) a shift from institutional base funding to programme, project or contract funding. In most countries many RTOs perform some amount of basic or applied strategic research and receive government funding on this basis, sometimes as core funding. But it is possible for RTOs to make the shift completely from core funding to fully independent revenue generation, as in the UK. Companies providing innovation services based in research and technology do not need to be public or semi-public in institutional form in order

to provide cooperative or collaborative research services under programme funding. However, sustaining their membership base or networks depends to some extent on continuity of funding for cooperative and collaborative R&D, as a factor affecting the stability of the membership revenue. Arguably, sustaining their broad capability in science and technology also depends on core funding (or stable, dedicated programme funding). However, the UK case shows that even this argument may not hold. See Box 8.

Box 8 Surviving without core funding

AIRTO (the UK association of independent RTOs) welcomed the 1993 White Paper from the Office for Science and Technology, despite the fact that members at that time received what AIRTO called a 'small and falling amount' of their income from government grants - an average of 7%. That White Paper put a stop to the main programme funding for RTOs - the General Industrial Collaborative Projects programme. Despite their claim that this kind of funding was essential in order to maintain basic competences, AIRTO formally welcomed the opportunity to demonstrate RTOs' effectiveness as technology transfer, Foresight and basic research organisations within the framework established by the White Paper. Since that time some programme funding for collaborative R&D has been restored by a new programme - Faraday Partnerships, up to twenty of which will be funded by 2002. This involves RTOs as bridging institutions and 'translators' rather than basic research performers. This is a role which is very acceptable to ex-RTOs operating without core funding.

The Faraday programme involves both 'system failure' and market failure elements - the latter for funding of basic research in universities and the former for funding the 'industry facing' activities. There is an assumption that, as the institutional linkages and genres become established (ie, system failures are gradually overcome) a market may eventually operate in this second domain, creating a new kind of composite network-management, collaborative R&D and 'bridging' KIBS activity.

RTOs are the empirical focus of RISE but in a sense they are only a tactical focus or a gambit. The true object of our research attention is the emerging economy of innovation services as a subsystem of a service economy. This is a large issue, and RTOs provide a relevant 'bounding' device for a limited and exploratory study such as the present one. RTOs are relatively visible as institutions (although statistics are not easily come by in some countries). Their core activities belong to a subset of innovation services, namely ones related to technological innovation and diffusion; thus RTOs as objects of policy straddle the awkward categorical boundary between 'science' policy and industry policy or competitiveness policy. Almost all RTOs increasingly must establish themselves as viable operators to at least some extent in markets for services to firms. Thus they provide examples of ways in which service orientation has influenced the development of organisations based on the delivery of technical resources into the wider economy.

From the point of view of institutional change, the central issue is that RTOs originally were creatures of policy. They were partially (or wholly) funded by governments to serve industries or diffuse technologies, controlled to differing degrees under various forms of governance ranging from government ownership and management (ie part of the civil service), to public charters (for example, the Fraunhofer Institute in Germany or TNO in the Netherlands), to arm's length influence over independent organisations exercised via individual contracts for projects within public-funded research programmes, or programmes of work on a customer-contractor basis for government clients. Thus, RTOs instantiate many of the complexities of governance and 'distributed government' that underlie current strategies of government in advanced countries.

They also constitute indicators of one of the key processes in economic restructuring in recent decades, namely deregulation, liberalisation and privatisation. In this broad context the basic issue pertaining to RTOs, as historical institutions, is whether governments should continue to fund them, and if so, on what rationale? The rationales under which governments might continue to fund activities by RTOs - and the modes or mechanisms through which funding is converted into significant competences - need to be made clear. RISE workpackage 3 deals with the two basic rationales, market failure and system failure (or 'market failure of the second kind'). See Norgren & Hauknes (2000) and Appendix 8 to the present report: *System failures*.

4.3 A changed perspective on the RISE core questions

The RISE investigation was originally framed by three questions:

- Q1 How to map the changing shape of innovation systems with respect to knowledge intensive business services?
- Q2 How to identify the right working balance between public and private sector agents as innovation intermediaries, and the implications for channelling public funds?
- Q3 In the context of globalising markets and the continued emergence of knowledge-based competition, how to steer systems of innovation agents via policy actions towards greater strategic competence at firm, cluster, region and country level?

We have learned some things during the course of our research. Consequently, and consequentially, we now wish to interpret our three framing questions differently. The revised versions appear thus:

- Q1 revised: How to map the changing shape of innovation systems (at national level and also, importantly, at cluster level) with respect to the different bundles of *innovation functions* and *competences* that are available from *different kinds of service providers*?
- Q2 revised: How to identify working relationships between firms, government and various *differently governed institutions* involved in the economy for innovation services (government funded, private non-profit, fully commercial, etc) which are appropriate in the context of sustained competitiveness of firms in various *significant innovation clusters*?
- Q3 revised: How to identify the strategic competence requirements of particular kinds of firms in key clusters, and address *lack of fit* between these requirements and the innovation services and competence resources available in the cluster? How to *match* these requirements with appropriate services using levers available in the form of various practices of government (funding, purchasing, regulating, etc)?
- Q3a How to evolve *the competences of policy bodies themselves*, understood as 'systems properties' of configurations of hard and soft institutional elements: staff and networks, programme budgets, hard and soft assets, languages and rhetorics varying across departments, funding formulae, etc?

The following paragraphs outline the rationale for these changes.

4.3a Q1 - Mapping. From KIBS firms to service functions

In the original Q1, knowledge intensive business services (KIBS) is a term inherited by RISE from a preceding TSER project, SI4S[3]. It is a fuzzy term, perhaps best seen as a residual category (containing activities too emergent, dynamic, tertiary to be stable) rather than a true category. During RISE it has been unpacked and as a result of three more specific analytical distinctions the term has been displaced to the margins of the research picture. First, 'knowledge intensive' *firms* (for example, firms having a high proportion of professionally qualified staff; this was a core element of the SI4S definition of KIBS) are now distinguished from 'knowledge intensive' *services* (which we interpret as services that supply competences to clients). This is a particular application of the general principle of RISE, that a functional rather than an institutional mode of analysis is required. Second, because RISE has shifted its primary focus from institutional classifications to systemic functions, it therefore analyses the bundles of *innovation functions* offered by various kinds of service-supply organisations, including what SI4S referred to as KIBS as well as RTOs. On this basis RISE examines whether the profiles of functions in KIBS firms are the same or different from those of RTOs. Thirdly, in the interactive context of an innovation system, RISE focuses on an output measure - the content of a knowledge intensive business service as delivered (analysed in terms of offered and received competences) - rather than an input measure: the 'knowledge intensity' of staff in a supplier organisation.

RISE is about mapping, as Q1 makes clear. Maps are systemic and systematic representations that have an 'interest' (Wood, 1992: *The power of maps*); Wood points out: 'Maps show this... not that'. As selective representations of the world, they are defined by the interest that they serve, the 'tool' that they are shaped to be; *maps show people where resources and goals are*, and are themselves resources for *getting somewhere or something*. The main issue in developing an innovation system map consistent with RISE principles, is that it should be a function map rather than an institution map. Typical maps of national systems of innovation are basically institutional maps that serve as financial accounting tools: maps of financial relationships between formal organisations (so-called 'hard' institutions: see 4.2d above). The flow of public R&D funding typically provides the skeleton of such maps. For example, Figure 2, Appendix 2 presents a map of the Norwegian national innovation system as a funding system.

Such maps are useful (not least, for administrators). But in contrast we wish to develop a mapping approach that facilitates the steering of innovation systems. It should show actors and relationships between actors in terms of the contributions that they are in a position to make to innovations in firms. It should present itself as a manifold of services available to an innovating firm[*]. As a tool it should serve the interest of institutional learning (institutional change, construction of new competences) in the course of handling system failure in innovation systems. That is, the map should facilitate dialogues between actors in the system about where there are resources that may be under-used or misrecognised, and which institutional locations are available or need to be constructed for bringing those resources into play in new ways. This kind of mapping tool is more concerned with 'soft' institutions (interpretations, conventions, established competences) than 'hard': it will need to be a map of interpretations, to map stuff (competences) that are normally and conventionally organised within the framework of hard

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[3] *Services in Innovation; Innovation in Services*, TSER project ERB-SOEI-CT-96-1015. Results are at: http://www.step.no/Projectarea/si4s/

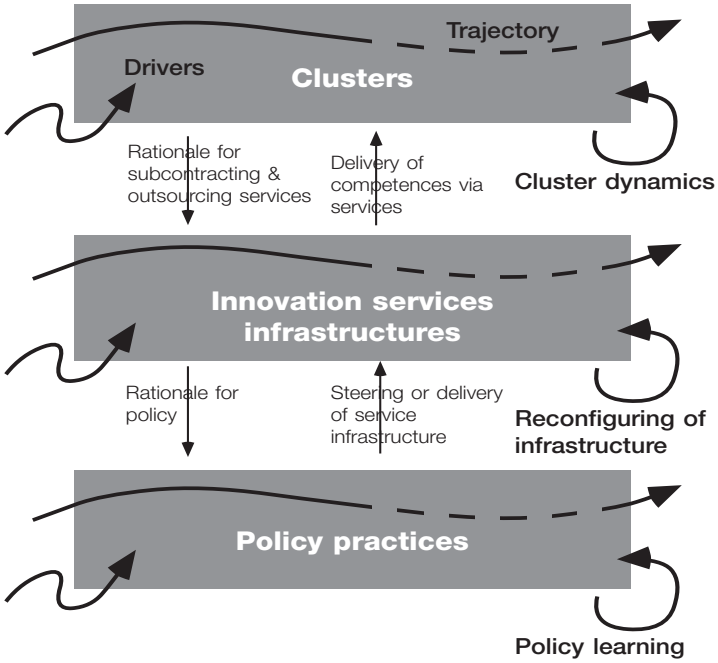
[*] Manifold: Showing number and variety; having various forms, applications; (literary) a copy or mechanical translation of a significant text hand-made by a manifold-writer; (petrol engine induction manifold) the branched pipe which brings the ignition mixture to the cylinders.

institutions (formal organisations such as RTOs, public labs, university research groups, partners in the supply chain, government policy agencies) but need to be interpreted out of that context, as being newly useful in some other action setting.

This is a tall order. Such a design brief can only be fully met by dialogue with the client and by trials of prototypes; so in the present context we have simply tried to produce a first-cut version of the tool, ready for the user dialogue. This rationale of this process is outlined in Appendix 2, Section 2.6.

The first RISE prototype of an innovation system map appeared in the Year-1 interim synthesis report, and is shown as Figure 10□□.

Figure 10 **A national system of innovation as seen earlier in the RISE project**



This version is useful to the extent that it identifies subsystems of an innovation system which are being addressed by RISE (cluster systems of innovation, systems of innovative policy practice, and 'service infrastructure' systems). An important part of the institutional insight embodied in the 'innovation systems' view of economics is that particular institutions have their own histories, assets and modes; it is this that makes it possible for systems to fail, in the sense that their potential flexibility and variety is unrealised in practice. Our RISE maps also usefully stresses dynamics (drivers, trajectories, learning) in a system of blocs that otherwise might look static.

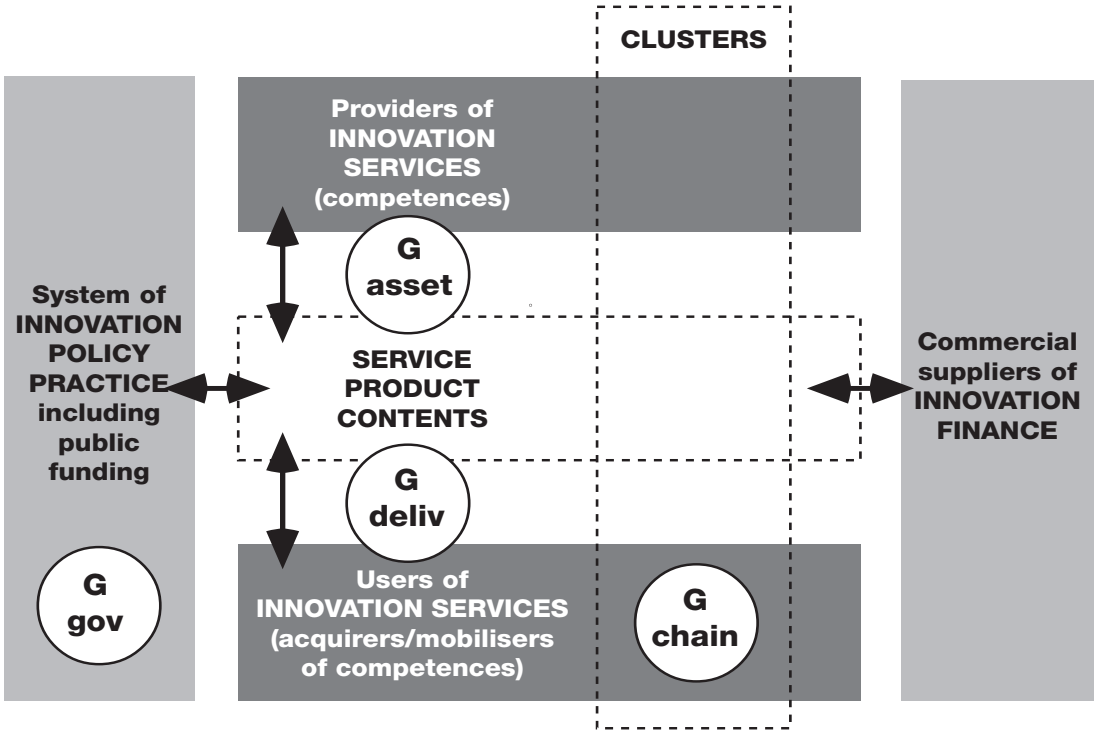
However, the map is still more of an institutional map than a function map, identifying three broad 'estates' holding different interests in innovation. It is open to misreading: each of the institutional blocs represented in the Figure should be understood as intersecting in practice with the others (that is, individual organisations - firms, government agencies, RTOs, etc - participate in multiple roles within the different subsystems, and thus 'weave' it in practice into a single

fabric). Our map implies that government (the system of policy practice) interacts with cluster systems only through a (separate?) infrastructure of innovation services. There is a kind of truth contained in this, which can be expressed through a maxim: *Innovation policy is not completed until it has become an innovation service; and services are not completed until they are received ('seized') by specific firms as competences, in the operational-competitive context of their cluster*. There is a sense in which a policy cannot connect with other practices in society unless it becomes a service to them; or at least, if it connects in any other way it is not a service, but an act of fiat. If policy is not producing services (in a public service sector!) what *is* it producing?

Our improved map needs to avoid the failings of Figure 10□□.

We arrived at a schema which represents a system of innovation as a hybrid system of services. It has at its centre a dyadic relationship between service provider and service user. The schema is shown in Figure 11□□.

Figure 11 **An innovation system as a focused system of tacit and explicit services and other forms of collaboration involved in innovation**



In Figure 11□□ the circles represent 'soft institution' relationships of governance as outlined in Section 2.1 above: asset governance (G asset), service delivery framework (G deliv), supply chain governance (G chain) and governance in the post-modern State (G gov). Only the first two of these concepts have been expanded by our study; the others remain outside the framework of the present research.

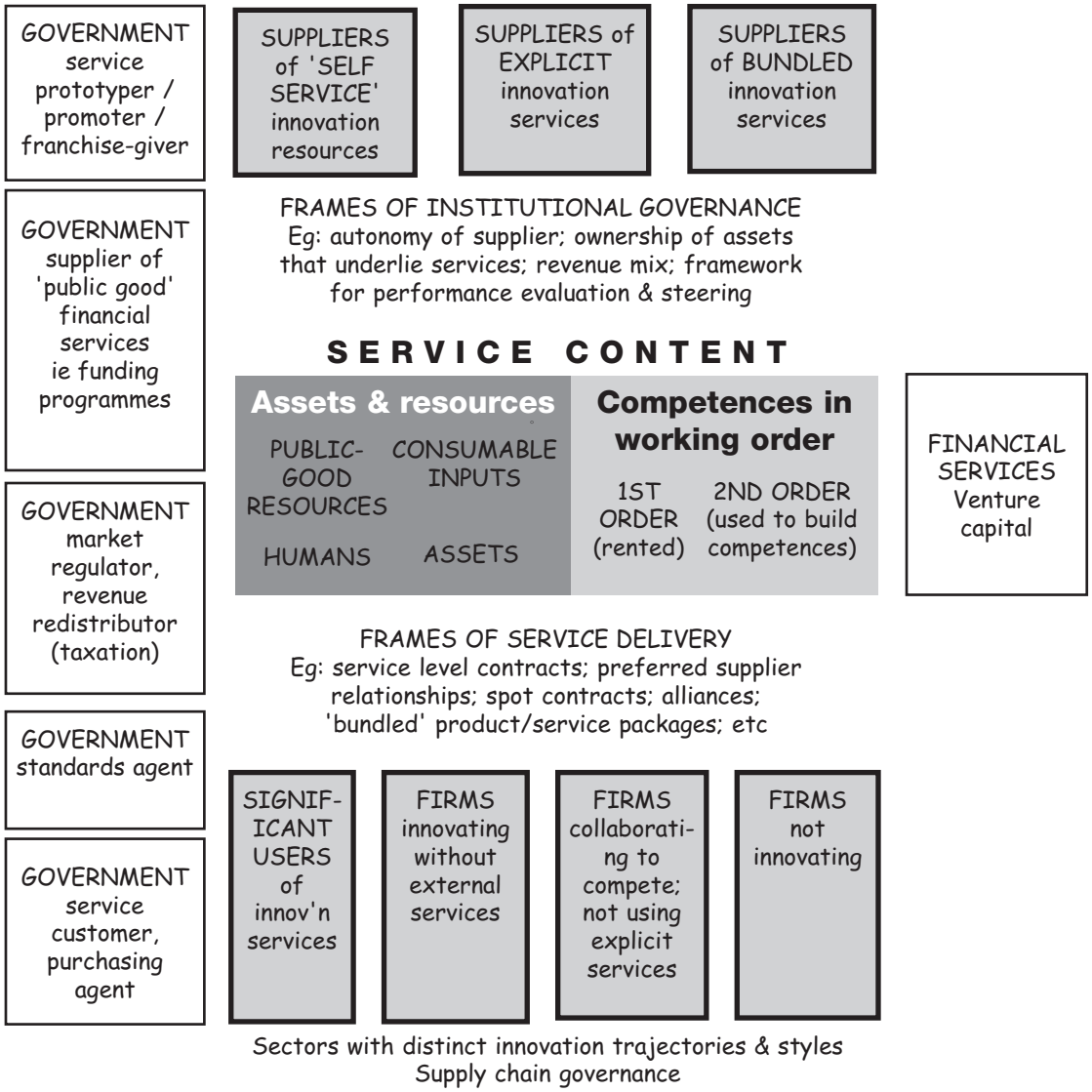
- Asset governance is central in defining RTOs. It is in this dimension that RTOs are constituted, as organisations receiving public money, enabled to hold various assets and expected to deliver various benefits from these. We have been forced to recognise that RTO services are distinguished most clearly by this institutional dimension (the 'financial services' function conferred by the involvement of government funding in an RTO) and the way that it affects the formulation of an RTO's service products and their delivery, rather than any other particular kind of (scientific or technical) functional content of their service output.
- Delivery frameworks vary according to the mix of service content being supplied and the complementary competences and assets being mobilised by the client. These variations generate different costs of service, and distributions of costs between the parties involved. These issues are examined at the micro-level in our case study analyses of service delivery as 'competence supply'.

The above schema can be developed in more detail as a mapping framework for cluster systems of innovation (also, systems defined at other levels) as shown in Figure 12□□ (reproduced from Figure 2, Section 2.2 above). Appendix 2 provides a commentary on this map and its rationale. Here we repeat what we said in Section 2.2 regarding the 'hybrid' characteristics that are called for in mapping an innovation system, and which the map in Figure 12□□ facilitates.

Figure 12□□ represents a 'hybrid economy' in three senses. First, the map contains public and private institutions and publicly and privately funded activities. This supports one of the basic aims of RISE, mapping the relationships between public and private contributions to 'innovation infrastructure', without making prior assumptions about the relevance and content of one or the other. Second, it contains tacit and explicit services. This reflects one of the characteristic aims of RISE, to develop mapping strategies that do not privilege the explicit, abstracted and exchangeable (classic characteristics attributed to scientific knowledge) over the tacit, embodied and 'sticky' (characteristics of informed in-context actions, competence).

And third, the map includes services whose orientation is innovation along with others whose orientation is routine operations. This is consistent with a tension that exists between images of innovation: on one hand, 'creativity' that generates competitive advantage, 'creative destruction' accomplished through radical product and process innovation, etc; on the other hand, the routine nature of innovative activity as a basic qualifying criterion for participation in many markets, the mundane nature of continuous improvement and incremental innovation. This suggests a possibility that in future we should orient to 'knowledge intensive' production activities *per se* in other organisations (ie both manufacturing and service sector) when mapping the possibilities, for a given firm, of acquiring competences and innovating via interactions with other organisations. Firms learn by collaborating without necessarily paying for services. This is quite consistent with taking cluster as our core mapping concept rather than sector: interactions between firms, including knowledge based firms (and including KIBS firms in this), are at the core of clusters mapped for innovation and competitiveness policy purposes, rather than the activities of specialised knowledge-based organisations in the 'RTO sector' or university sector.

Figure 12 **Function-based map of an innovation system as a system of tacit and explicit services**



4.3b Q2 - Balance. From institutions to working relationships

The distinction between public and private sectors in the original Q2 has broken down. It now needs to be handled in terms of the forms of governance that apply in the management of assets in a service-providing organisation (institution governance) and in the performance of a specific service (interaction governance). The rules of asset-ownership and norms of performance evaluation that govern the mobilisation of assets, for example, differ between classically public and private organisations. But also, many non-classical forms exist, including various forms of agency coming under government influence via ownership, funding, regulation and other mechanisms, on either a temporary or permanent basis (eg individual funded projects or time-limited programme-funding agencies in the former case, or chartered institutes in the latter). In addition many hybrid forms of service-providing organisation exist, including government franchises operated on a private non-profit basis, and collaborations or networks involving government, private non-profit organisations and commercial firms.

RISE set out to explore the functional characterisation of RTO services, and on that basis to improve the resolution available, for policy purposes, in describing the services that RTOs and KIBS provide. As it turns out, this radical 'function-ist' position has not been sustained. It now seems clear that the institutional characteristics of RTOs are among the most important things about them. This is not surprising: RTOs are significant precisely because of their institutional locations (especially with regard to funding flexibility and the rationales for funding). The innovation-related functions supported by RTOs may or may not differ significantly from those of commercial firms (KIBS). But the conditions under which they deliver their services - and thus the differentiated accessibility of those services for various kinds of user firms (and so also, on one interpretation, part of their actual content as service products) - depend quite strongly on the institutional form (asset governance) of the service-providing organisation. Thus RISE finds itself forced into a more detailed consideration of the institutional forms of RTOs.

As regards 'channelling public funds', we recognise that funding is not the only mode of involvement of government in the innovation-services economy, nor necessarily the most significant one in any given situation (although it is always a powerful dimension). The picture needs to include reference to multiple channels of government 'steering' influence: as a service funder, asset owner, service supplier, service prototyper, provider of financial services (eg scheme funding), market regulator, technical standards agent, revenue redistributor and service purchaser. Individual RTOs may be involved with government in numerous of these modes related to innovation, and also in other modes connected with some other function of government (eg literacy, culture, social exclusion or democratic process) rather than with the innovativeness and competitiveness of firms, the provision of services to corporate clients or the behaviour of markets. Thus other channels may also be relevant in the steering of RTOs.

The important thing about channels is what flows through them and what this accomplishes downstream. The important thing about RTOs' services is their content - what they do for firms using them. Our original perspective on service content or the functions met by services was that these might be specified abstractly, via a generic model of the innovation process. We discover that such a model (at least, at the level of abstraction that we have explored) does not discriminate very strongly between what obviously are different services and different mixes of service, provided both by public-funded RTOs and commercial KIBS firms. Rather, the institutionally concrete relationships between the service supplier and the context of use have come to the fore. In RISE we explore this relationship most thoroughly as 'cluster'. We can see that means of meeting the 'same' function - for example, prototyping or product R&D - may be furnished in very different forms (as substantially differing service products) to firms differently located in different clusters subject to different drivers of competition and innovation. For example, the functional relevance of a prototyping service to a small biotech firm (where establishing and exploiting intellectual property is a central rationale for innovation activities, as distinct from industrial-scale production) differs from that of a prototyping service supplied to an OEM supplier of automotive components (where capital reduction and time-based competition are strategies that determine the productionising of designs and the sinking of capital in production tooling).

The difference between the two service products is not just the difference between molecules and metalworking - in fact, in both domains, one common function is the management of translations from the virtual world of designs, representations and professionals' discourses to the material world of artefacts and 'stuff'. Rather, the difference lies in the rationale behind what the client plans to do downstream with the 'verified' artefact or stuff. The biotech firm may want to market the IP; the firm in the car-manufacturing supply chain wants to get into a manufacturing

operation with minimise risk. Different locations in different value-chain systems generate different service requirements around 'the same' function.

'Significance' enters into the revised version of Q2. Clusters are constructions, reduced scale innovation systems identified for the purpose of analysis and action. They are not natural objects. An economy might be constructed as an indeterminately large number of differing clusters, differing in scale, technology focus, geographical scope, and so on. Within RISE we have constructed clusters in several different ways, as an illustration of a 'menu' approach to cluster analysis (how you construct a cluster for research purposes depends on what you want to do with the resulting knowledge in a policy context). Thus clusters need to be chosen because of their significance - ie, on the basis that significant actions might be taken via that particular identification of cluster content and boundaries, and that the economic outputs of the cluster are sufficiently significant - on some criterion - to balance the opportunity costs of neglecting some other cluster. Although the choice may be informed by research and theory (for example, by welfare economics, or a wider system model) this is ultimately a political choice, made through political processes. In the revised version of Q2 we stress the choice element in cluster policy.

This is part of a message generated in our analysis of rationales for innovation policy. See the literature review for workpackage 3, *Economic rationales of government involvement in innovation and the supply of innovation-related services* Norgren & Hauknes (1999) included as an Appendix to Norgren & Hauknes (2000). A change of policy practice from the optimising policy maker to the adaptive policy maker is implied. Policy is no longer only about correcting imperfect incentives for private agents but rather about facilitating the emergence of new opportunities by building innovation infrastructure. Since policy making cannot be optimising, it follows that there is no room available for any variant of the social planner. The emphasis of adaptive policy making is upon co-ordination of actions leading to innovation by non-market methods recognising that once innovations occur they will be co-ordinated by the market process. Such policies are to a large extent trial and error experiments. Policy experimenting and formulation must be based on a mixture of theory (important variables), measurement (indicators, benchmarking) and subjective judgement; this mix is part of the make-up of the RISE cluster approach. Hence the prompt in our new version of Q2, for the significance of a cluster to be subjectively assessed via modes of rigour appropriate to the political setting.

4.3c Q3/3a - Steering. Of systems? Of strategic collaborations?

Following on this point, and regarding our original Q3, RISE takes the position that there is no automatic rationale for how a government should relate to innovation service organisations. In particular, once an innovation systems perspective is adopted there are many possibilities for 'institutional' failure, mismatch or lack of fit within the system, as distinct from classical 'market failures'. For example, resources held by one institution may not be visible to another as a consequence of geography or culture; or may be interpreted in an inappropriate way by some actors in a profession or sector; or forms of communication between institutions may be inadequate. Although market failure is deemed by classical economics to be an absolute principle with identified legitimate responses by the State, institutional failure is relative to an action context, and is essentially a negotiated concept. Institutions may 'work', but not in the same way as in other national settings, or not well enough to meet the medium- or long-term expectations that cluster actors have regarding competitiveness, resource exploitation, dynamism and sustainability.

Further, possibilities for institutional failure materialise in different ways in different cluster contexts. Thus 'the right working balance between public and private sector agents' is a matter for interpretations that are local to clusters and countries, regarding the lack of fit between existing capabilities and reasonable expectations of performance in a given context. 'The right balance' may be determined partly by reference to formal benchmarks. But it is not necessary to have a fully comparable comparator system before evaluations of 'failure' and desirable improvement are made. With a concept like the 'steering' of a complex cultural-historical system like an innovation system, we are in an action rather than a calculation frame; thus, plausible storytelling (rigorous, conscious of the facts) is the basic mode that evidence takes, as distinct from - though not in opposition to - scientific proof and controlled comparisons between datasets.

Putting this another way, in an action-research context it is better to interpret 'steering' as referring to the courses of action of collaborating actors in strategic partnerships (who act on-and-in the system) rather than to the system (as if it were a 'thing' that can have a single location or trajectory). An innovations system is a construction, and thus 'steering' acts by steering the evolving constructions that actors make of the system (through 'research' and dialogue) and of plausible and justifiable actions within it ('action', agreement and coordination of action). Rather than steering the *system*, we should picture cluster analysis, competence analysis, function analysis and the other conceptual tools of RISE as tools for steering and inflecting the *courses of action* of strategic collaborations (communities of practice) of cluster actors.

The reference in Q3 to globalisation and knowledge-based competition stands. Globalisation is a significant criterion for identifying the key clusters in a national economy which should receive policy attention. Their positioning in transnational supply chains and markets is an important characteristic for identifying specific classes of firms that warrant targeting both by government programmes and by individual RTOs seeking to develop effective services. The reference to 'innovation agents' also stands, although now interpreted in terms of various players in the economy for R&T services, including bundled service suppliers and operational services.

'Strategic competence' is interpreted by RISE in terms of the scale of impact of innovation services in client firms. The notion is meaningful at the level of individual firms and also in clusters, via the strength of the interactions that individual innovative firms have with other organisations in a cluster. Strategic competence at region or country level is not a concept that receives any particular interpretation from RISE. However, the capabilities of regional and national operating units of government, and the competences called for in policy practice, are concepts that would bear further investigation. The direct application of competitiveness standards to government activity clearly will not apply, and thus competence is a concept that needs to be adapted. However, the analogy with the competences of a firm is probably well-founded within the RISE model of a competence as a behaviour of a hybrid socio-technical system that is subject to management; and the strategic capability of a policy body or agency would meaningfully be interpreted in terms of the institutional 'fit' of policy practices with the dynamics and requirements of significant clusters.

The relevant competences of policy bodies are understood to span a wide range of government activities. As referenced in Appendix 1 and Section 4.3a, Figure 12□□ abo**ge**vernment activities through which 'steering' of innovation systems may be executed include:

- Funding innovation services and activities (directly funding innovating firms, operating advice centres, operating government labs, etc), service franchiser/charter-giver, funder

(of public sector R&D, higher education, innovation programmes for industry-academic collaborations);

- Regulating markets (eg competition between RTOs and KIBS); issuing and maintaining standards (for products and technological interfaces, for manpower, etc); and
- Purchasing innovation services (eg defence research contracts) and operational services (eg forensics, testing, systems maintenance).

In this context, the behaviour of government itself needs to be seen as a strategic collaboration rather a simple mobilisation of a monolithic entity. We understand 'steering' of a system as a matter of situated, coordinated, hands-on action by many actors working with many resources and in many media within a system (including actions of research or reflection and actions of mutual coordination) rather than directing from a seat in the clouds using a map that is fully featured and finished before it is even used.

4.4 Policy learning - National conditions for the adoption of RISE-related strategies

4.4a Policy environments

The following characteristics of policy environments in the six countries where RISE has done policy research (Germany, Netherlands, Norway, Portugal, Sweden, United Kingdom) are relevant to the possible uptake of RISE results by policy practitioners:

i) Although increasing industrial funding is the norm, basic government funding contributions to RTOs vary substantially. Portugal, Germany and the Netherlands have relatively high levels in marked contrast with the UK which has no public base funding for the majority of RTOs.

ii) The RISE/NIS view is that some degree of cluster specificity is called for in innovation policy. However, there currently is little policy addressed specifically to innovation in clusters - as distinct from generic measures aimed at technologies, sectors or SMEs. In part, this results from a reaction against 'picking winners' as a form of policy. Where 'clusters' are addressed this often refers to a geographical entity rather than the kind of innovation system identified by RISE.

iii) Government sponsorship of cooperation between firms (a 'system-failure' rather than a market-failure policy response) is widely adopted as a policy goal. For example it has been evident in CEC policy since Framework 3. However, it has been established for differing lengths of time at the national level and is not yet well established in Portugal and not yet deeply embedded in German policy culture.

iv) Absorption of knowledge or innovation services by firms is not uniformly stressed. In Germany, Portugal and Sweden a strong emphasis on university research may sometimes be detrimental to the emphasis on development and absorption of knowledge by firms.

v) Policy benchmarking or some other form of evidence-based, evolutionary design and development is tacitly or explicitly established as a practical interpretation of policy

learning in at least some relevant sectors of government in four of the six RISE countries (but apparently not in Germany or Portugal).

Benchmarking is a widely used term with varying meanings. Bessant and Rush (1998) note that where benchmarking is the form of improvement adopted a distinction needs to be made between:

- Benchmarking of the external performance of economic systems (for example, applying arrays of indicators to produce league tables as in OECD (1999a)); and
- Benchmarking of the internal elements and relationships of industry or government systems, for purposes of in-context reflective learning by actors and self-managed continuous improvement of their working practices.

RISE results are relevant within the latter context, as an approach to policy learning as an *operational* activity embedded in the day-to-day improvement and tuning of action.

The countries involved in RISE can be divided into three groups with regard to this kind of application of RISE results as 'improvement tools':

- Sweden and Norway - A technocratic division of labour exists between ministries and policy agencies. This has led to commonplace use of evaluations of policy delivery, and to an 'improvement' culture in the agencies as part of their relationship with policy 'principals' in their client Ministries. Policy benchmarking is a familiar concept in these settings (and other Scandinavian countries with a similar institutional structure).
- Netherlands and UK - These countries have a different division of policy-making and execution and different structures of RTO infrastructure. But in both cases there are at least significant segments of innovation-related policy practice that display a 'benchmarking' or continuous improvement ethos, and these may be viewed as potential clients for RISE models and methods. Some patterns, formulae or policy 'platforms' for policy action seem to be sustained over quite long periods, as soft institutions, and some degree of craft skill has been developed for tuning and adapting the policy content delivered via those vehicles. Old 'mentalities of policy (Hauknes & Wicken, 1999) may leave behind platforms of administrative apparatus - and, importantly, routines, resources and rhetorics (genres, stories, language games: see the analysis of competence and memory in workpackage 5: (Hales, 2001)). These are sometimes usable to assemble and deliver other kinds of policy and services via a kind of continuous improvement and bricolage; and sometimes they get in the way, and 'work-arounds' have to be put in place instead, to make it appear as if what is being done is being in the old, approved manner. These matters are contingent.
- Germany and Portugal - In both these countries (although for different reasons) 'benchmarking' and similar systematic concepts of improvement in policy practice may not be well fitted to the dominant political culture. This does not mean that RISE models and methods are inapplicable, but it may be more difficult to find clients for continuous improvement usage as distinct from applications in the formation of new policy.

4.4b Research and policy making, another linear model?

Since the late '80s the systemic view of innovation and technological development has come to the forefront. In a ritualistic manner both policy documents and research reports often open their

analysis declaring 'the death of the linear model', meaning the end of the view that new ideas and concepts normally are born in university science laboratories and offices. Policy makers and politicians often use arguments based on modern innovation theory rather than the linear model, ie a view where innovation is seen as the fruit of cross-institutional collaboration or an efficient flow of competences, knowledge and ideas in a larger network of firms, organisations, public institutions and regulations. However, discussing these matters with researchers and policy makers, one soon gets the impression that this way of thinking is in no way taken for granted.

'We all say that the linear model is dead,' an interviewee told one of the Norwegian RISE researchers, 'still a lot of policy makers act as if this is not the case. Maybe they have not grasped the true implications of the new way of thinking, or maybe they find it opportune to use more old fashioned arguments.'

RISE studies show that there is no simple explanation for this phenomenon - see the synthesis report from workpackage 4 (Koch & Hauknes, 2000). No country has a monolithic policy apparatus characterised by total ideological consensus and common goals. Instead one will find large variations as regards ways of thinking, policy strategies, educational backgrounds, historical traditions and institutional frameworks. We have found ministries where the worldview in one department differs significantly from the basic concepts used in another. We suggested earlier (Section 4.3c: page 74) that government itself needs to be seen as a massively-parallel system of strategic collaborations rather than the working of a monolithic machine.

Policy-making milieux are no different from academic circles where one school of thought may compete with another. For instance, within innovation studies one continues to differ between neo-classical economics, new growth theory and evolutionary innovation theory. There are no absolutely clear boundary lines between the various schools, but the terms point to significant differences in pictures of the reality at the root of modern economic development. One will find some of the same dividing lines within the political apparatus of European countries, although in these environments the differences are not always formulated in academic terms.

There is no one-to-one relationship between social and economic studies and policy development. Strangely enough, researchers studying innovation and the systemic nature of competence building, often fall back to a quite linear understanding on how research on innovation and knowledge creation influence policy development, ie policy makers transform the objective analysis of researchers into relevant policy measures, which the administrative machine then 'delivers' as programme-spend and service output.

The RISE study reminds us, however, that the day-to-day reality of policy makers is much more complex. Research results are only one of many factors influencing policy development and service delivery. Policy makers and politicians must also bear in mind the importance of overall policy goals beyond the sphere of innovation and industrial development. Then there is the press and public opinion to consider, cultural and ideological differences, as well as the constant struggle between the various parts of the political apparatus for funding and power.

Although it may be that the success of a certain policy to a surprisingly large degree rests on the skills of individual managers, their individual capability is linked with the competences and competence-development processes (dynamic capabilities) of the policy system. Preliminary studies made by RISE may indicate that there are large differences between organisations as well as countries in this respect. It seems, for instance, that the culture of Norwegian and Swedish ministries are characterised by a rather flat command structure, meaning that junior civil servants

and policy advisers can communicate with the managerial level in a fairly efficient way. This means that the competences developed in co-operation with researchers more easily will travel from the officer level to the political level of the system.

Moreover, innovation policy is not highly politically or ideologically charged in these countries. There seems to be broad consensus regarding overall policy goals. This leaves more room for civil servants and agencies to suggest and implement new policy measures. Both Norwegian and Swedish R&D and industry policies are increasingly based on innovation systems theory, and this development is to a large degree based on bottom up initiatives, ie the new policy vectors are often based on suggestions made by the bureaucracy, as distinct from the political parties or the politicians. In other countries, for example Germany, policy development seems to be characterised by a top down and rather charismatic culture, meaning that the political level to a greater extent influence the limits of policy formulation. This may restrict the flow of new ideas from research and lower level civil servants.

4.4c Extending the policy repertoire through evolutionary policy practice

The concept of system failure as a means of approaching innovation in market systems (see Appendix 8) has not yet resulted in widespread and clearly understood practical repertoire of developments in the basic rationales of policy formulation and intervention. It is still experimental and exploratory. However, experimentalism (in the sense of evidence-based action) is also an intrinsic characteristic of 'system failure' responses. The policy shift towards recognition of system failure means a change from the optimising policy maker to the adaptive policy maker. Policy is no longer only about correcting imperfect incentives for private agents but rather about facilitating the emergence of new opportunities by building innovation infrastructure.

Discussing the shift from government to governance in a major study of UK policy practice and policy learning, Rhodes (2000) notes as a key characteristic the experimental nature of policy practice (along with other characteristics such as the 'hollowing out of the State' from above and below, by sub- and supra-national networks). He writes: 'Policies are theories about how to change the social world. Implementation provides findings on how that world is both changing and in so doing changing the policies.' On the other hand, Rhodes also notes as a key characteristic of the 'governance' mode of polity that 'all governing structures - markets, bureaucracies and networks - fail, so "if it ain't broke, don't fix it"'. This is consistent with the evidence of layers of old 'mentalities' embedded in the Norwegian innovation policy system (Hauknes & Wicken, 1999).

Endogenous and systemic innovation and technical change, implies that there is no longer any well-defined optimum allocation of resources. Hence, there is no single, optimal public policy. Rule based policies such as follow from a market failure approach are not any longer viable. Because policy initiatives are trial and error experiments, their evaluation is essential in order to check also for 'government failure' - ie, failure to learn and adapt (Lipsey, 1998; Metcalfe & Georghiou, 1998). Adaptive policy making in this mode requires a wider theoretical and empirical analysis than conventional strategies, and policy learning must be an integrated part of the policy making process. This shift in policy practice changes and increases rather fundamentally the requisite policy capabilities and competencies of policy makers (Smith, 1998).

4.5 Policy positions emerging from RISE findings - Ten principles

In our findings we identify ten core elements for policy related to RTOs. These are laid out below.

1 **Adopt a perspective of a hybrid economy of research & technology services (R&T services)**

RTOs are a small (sometimes marginal, sometimes significant) part of most innovation systems and account for a variable but always minority part of the explicit funding provided for innovation by governments. From the point of view of the innovating firm - as distinct from the narrow supply-side perspective of a traditional science-based, university-linked RTO - the spectrum of services sources for innovation is a broad one. Activities associated with scientific and technological innovation are not entirely distinct from operational activities involving technologies. Thus some service suppliers that support innovation may primarily be suppliers of operational services (for example, batch fermentation production facilities in biotechnology) and the core revenue of commercialised RTOs may in some cases come from operational support of technologies (for example, health and safety checks on nuclear installations) as distinct from innovation (for example, design of high-pressure plant). Further, some firms acquire most of their innovation input as 'bundled' services provided tacitly by capital-goods suppliers. Thus, some manufacturing or value-added equipment sales or leasing activities should be regarded as containing innovation services.

This perspective is embodied in the upper segment of Figure 12□□ abo□Rather than innovation services, the relevant spectrum should be treated as one of *research and technology services*. This broader concept covers not only innovation but also the operational management of systems of technology. It covers R&D of a traditional 'upstream' kind (as implied by the similarity of the terms R&D and 'R&T'). It also covers research in 'continuous improvement' and 'action learning' modes, where competences 'downstream' in a firm, in operations close to the market, are developed in a systematic and reflective way based on market research, customer feedback, continuous improvement and other 'non-science' activities such as organisation development. These R&D activities - typically focused on organisational innovation and market innovation - may be undertaken by consultancy firms, facilities management specialists, production subcontractors and other commercial actors, as well as (sometimes) by R&D groups in universities.

2 **Adopt a service economy perspective**

In considering the roles of RTOs a 'service economy' framework is more relevant than a science and technology framework. A model of economic networks containing innovation-services producers, providing many kinds of knowledge-intensive services derived from many kinds of source, serves better than a hierarchical, trickle-down model comprising a knowledge 'base' (seen as a science base derived from formalised R&D), users of the base and intermediaries between the two.

Service-related modes of innovation are now very significant in both service firms and manufacturing. Traditional technology policy is oriented to the production of knowledges and technologies in an 'upstream' infrastructure of basic and applied R&D activities, which are then 'transferred' to firms via intermediaries such as RTOs. Recent innovation policy recognises also the roles of intermediaries in transferring good practice between firms, sectors or countries, which has emerged 'in the field'. In advanced economies the functional capabilities required for firms to innovate are frequently provided on a service basis by public or private service providers - eg government-funded RTOs or KIBS firms. The models that support policy need to recognise a more complex, multi-content, multi-producer, multi-directional reality of innovation, knowledge production and the networks of 'distributed competence' that embrace far more than manufacturing industries and formal R&D establishments within the science base.

As indicated under point #1 above, knowledge intensive manufacturing firms often may need to be regarded as part of the network of supply for R&T services. This is consistent with an interpretation of the service economy in which manufacturing and service are no longer distinct sectors of activity, and can occur within the same organisation - for example, as value-enhanced manufacturing, 'complex product systems' manufacturing (eg telecommunications network supply, manufacturing of oil rigs) or 'product service packages' and asset-intensive deliveries of R&T services.

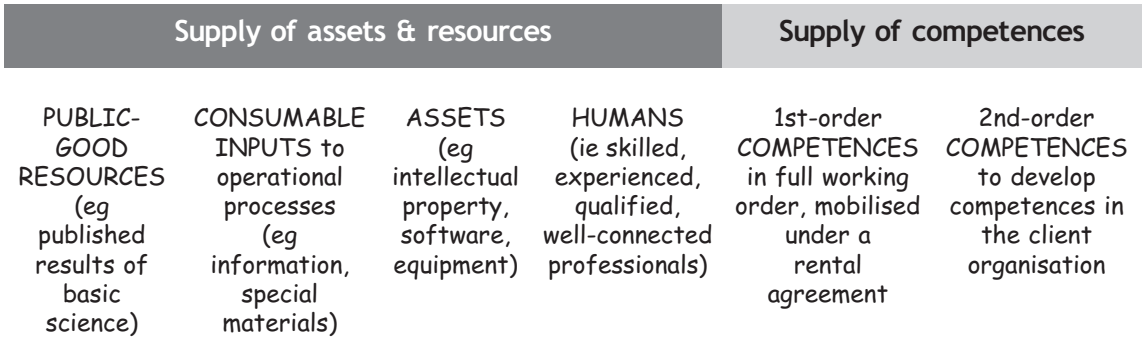
3 Build firms' competences to use external competences

In most advanced countries, articulating demand as distinct from increasing the supply of innovation services is the key issue. This strategy - pursued through 'systems failure' measures - can lead to the creation of viable markets for services once demand is educated and articulated. Firms need to possess complementary competences in order to channel or mobilise external supplies of competences or competence factors of various orders of 'stickiness': see Section 3.3e above and Figure 6 reproduced below as Figure 13.

The least ‘sticky’ resources can be provided via the purchase of goods/services in the market (e.g., new materials, publications). Others, like intangible assets (intellectual property rights, patents) can be transferred via negotiated arrangements within transactional frameworks. The ‘stickier’ ones, like human skills or innovation competences require quite different modes of transfer, such as learning, joint development of solutions, internships, alliances. Differently-usable services - with differing impacts in the user organisation - require different supply-governance frameworks or 'terms of engagement'.

Appendix 6 and Section 3.3b above have identified the concept of 'received' or 'seized' as distinct from 'delivered' services. This means that competences or competence factors (assets and resources in Figure 13) may be available either as explicit services (including managed learning networks, for example) or informally through collaborations and interactions (for example, collaborative R&D partnerships) that are not conventionally or very helpfully seen as dyadic, formalised, provider-to-client services. This message about competences to use services is thus a version of the widespread policy commitment to support 'collaboration to compete'.

Figure 13 **The scope of competence supply - A spectrum of stickiness in knowledge intensive inputs**



4 Using a range of 'channels' available to government in various roles, facilitate a sound division of labour in the R&T services economy between various kinds of suppliers and various kinds of service content

The appropriate spectrum of service inputs - including suppliers of tacit as well as explicit services - is represented in Figure 12□□ above: expanded further in Appendix 2. Pay attention to intermediaries rather than assuming that direct, unmediated transfer between the science base and firms will be the most appropriate route of technology transfer. System-failure programme strategies including 'bridging' institutions - perhaps on a national or wider basis, but within the framework of a cluster-system of innovation - are often important alternatives to direct 'local cluster' linkages between universities and firms in a geographical area that happen to come under the same political administration.

The range of varied technologies involved in an innovation process may easily outstrip the capabilities of any single source of technology and competence. In this situation, alliances between RTOs, on either an ad-hoc or an institutionalised basis, are increasingly common. In this respect, the total capability of an apparently fragmentary system such as that in the UK where there are numerous independent, trading ex-RTOs may become comparable in some respects to the capability of a large national core-funded RTO such as the Dutch TNO or an elaborate system of public-funded institutions operating within a formal division of labour - and funding - such as the German Fraunhofer/Max Planck system. The AIRTO 'umbrella' in the UK (*Association of Independent RTOs*) contains individual, privatised ex-RTOs which are growing in size, and also KIBS firms; a few of the latter possess significant technology assets. This voluntary network increasingly functions as a partnering system, through which combinations of competences and assets are assembled to meet contracts.

It should be noted that here we are referring to alliances and portfolios that expand the total range of complementary technology-specific or sector-specific competences available to a given project. They do not necessarily integrate any research and technology functions that are relevant to innovation or technology management but non-traditional for RTOs. For example, important 'non-innovation' functions include technology-facilities management, technology-systems maintenance, small-scale manufacturing operations; classic-KIBS functions include brand innovation, organisation development, strategy consulting, business development consultancy; and financial

services include venture capital and brokerage of project funding. Any of these may fall outside the integration framework of an RTO-based service alliance, and will need to be sourced in other ways.

As represented in Figure 12□□ and noted in Section 4.3 above on the 'steering' of innovation systems, the roles of government in a hybrid public-private economy of tacit-explicit R&T services are varied: funder, franchiser, standards agency, regulator, purchaser, fiscal redistributor. As the steering discussion points out, the behaviour of government itself needs to be seen as a strategic collaboration rather a simple mobilisation of a monolithic entity. Policy learning processes across the divisions of the policy apparatus - leading to service innovations in policy-making and policy-delivering practice - are an important part of a systemic approach to innovation.

5 Match services to cluster requirements, in strategically important clusters

These should not be limited to high-tech industries or 'the new economy'. A policy emphasis on high-tech new industry may also be associated with an emphasis on a network economy that is nominally 'new' or a knowledge economy which is 'new', implying replacement of the 'old economy'. However, RISE provides further support for regarding these significant structural changes as fairly general processes across the economic landscape of (old and new) production systems (see Hauknes (2000a; 2000b)). They are far from limited to 'new' (and generally small) industrial sectors based on new technologies such as biotech.

Rather than envisaging a new knowledge transfer *sector* or knowledge economy, RISE is defined by its concern with the new *challenges* of innovation management and innovation policy. These arise in systems of innovation in which competences are significantly distributed across organisational boundaries through networks (of short-term trading linkages, or longer-term alliances and service relationships) rather than being contained within individual firms. Our focus is on producing an appropriate new mix of management practices or policy practices (competences) in any significant sector of industry or industrial policy, and not on the proposition that the old economy is being supplanted by a new one.

'Cluster' is the core network concept in RISE. Cluster strategies in mature industries can be important, renewing the capabilities of clusters which contain substantial infrastructures, well-established networks and large amounts of resources. RISE includes some more mature clusters - even a cluster that generally is perceived as 'low tech' - in order to show that such clusters may have advanced ways of innovation and of providing innovation functions.

6 Facilitate and fund collaborative R&D in supply chains

The demand for explicit innovation services tends to be weak and there are systematic pressures in global supply chains that aggravate this. Firms that dominate supply chains - governments too, as procurers of technology - tend to displace risk on to smaller and more dependent actors in the chain. This reduces profit margins and deters innovation in SMEs particularly those in high technology supply chains trading in the global market. With few exceptions, SMEs engaged in supply chains have always found difficulty in

funding R&D. This includes finding the means to upgrade their innovative competences. Thus articulated demand for the service that RTOs seek to sell, as government reduces their core funding and programme funding, is typically not strong among SMEs.

This is not just a matter of reducing financial risk (a classic market failure). It is also a matter of cultural processes (learning, competence development). SMEs, supply chain partners, RTOs and universities do not have sufficient opportunity to develop the competences of working in a service relationship, including assessing and managing the risks of this kind of collaboration. Thus promotion and facilitation of collaborations in R&D (a system failure corrective) is also involved. The European Framework programme provides a significant source of funding for collaborative R&D, and national governments typically supplement this with core or programme funding for RTOs to perform collaborative R&D (perhaps within some prioritisation framework such as Foresight or a key-clusters strategy). The scale of this type of funding varies, and in some countries such as the UK the levels of this type of funding have been substantially reduced. As a market- and system-failure corrective, this kind of funding is important.

7 Assess RTO contributions and requirements in specific clusters

Innovation by firms occurs not in isolation but in networks and partnerships, and therefore concreteness (of links, of resources, etc) and context are keynotes of a cluster approach. As far as their role in innovation is concerned, RTOs should be contextualised within innovation clusters rather than treated as part of a broad knowledge-transfer 'sector' or infrastructure. Cluster analysis and cluster policy provide a way of customising innovation programmes, pre-existing policy 'platforms' (eg SME support schemes, regulatory measures for IP markets, tax regimes to stimulate R&D, etc) and other policy apparatus (eg public infrastructure resources in labs and universities, regulatory machinery) towards the specific needs of a cluster and its innovation dynamics. Innovation policy is not completed until it has become an innovation service; and services are not completed until they are received ('seized') specific firms as competences, in the operational-competitive context of their cluster.

Where public-funded or sponsored innovation infrastructure is the concern, the basis of policy analysis should be: *Existing clusters first, emerging knowledge economy second* (ie 'the knowledge sector' containing RTOs themselves and other innovation services firms). It cannot be taken for granted that an RTO, as such, is a significant actor. While being a viable, good-quality supplier of services (perhaps on the basis of a diversified cross-sectoral client base) an RTO or KIBS firm may still be marginal to the innovation dynamics of a given cluster - being displaced, for example, by other actors such as equipment suppliers, trade associations, labour-supply institutions or powerful firms at the head of a supply chain. Perhaps RTOs in this situation should be firms rather than receiving public funding? RTOs may be poor performers because there is no competition in the cluster. Perhaps discriminating customers - supply-chain leaders - need to be put into the market 'mix'.

A 'knowledge transfer sector' comprising the national population of RTOs and KIBS is a problematic concept. If we view it, as we must within the RISE context, as a cluster rather than a sector, then - like the biotech clusters studied in RISE - it must have very many subclusters. And like them, the dynamics, actors and relevant strategies in subclusters

will differ substantially. It cannot be taken for granted that a cluster definition based on such a broad and abstract function as 'knowledge translation' will have practical coherence or give targeted value-for-money as a programme focus. Perhaps some technology-defined subset of the 'sector' containing a limited number of RTOs (perhaps targeted using Foresight maps of significant technologies and user industries), rather than the entire national RTO population, might be an appropriate way of exploring such a cluster concept. Broad market failure policy instruments and system-failure programmes may have a bearing on the entire RTO/KIBS 'sector. For example: formulations of intellectual property law, definitions of tax exemption for R&D-based companies that do not receive public core funding, or programmes that assemble 'upstream' and 'downstream' actors in innovation processes together with industry-facing 'bridging' actors. Such broad measures will have relevance if, as *inputs* to cluster policy, they are targeted to RTO (and KIBS) clients within the frame of specific clusters, along with a 'layered' portfolio of other specific or generic measures and instruments, so that their transformation into significant service outputs (supplies of competence that match cluster requirements) can be ensured for relevant classes of firms.

8 Identify actual content of innovation services provided by RTOs, labs, etc

Actual RTOs contain many actual mixes of economic and social-cultural functions. The mix differs substantially between countries (for example, the higher-education and basic-science components of RTO activity). Even within a single institutional category in a given country (eg government labs, universities) standard institutional labels are a weak basis for identifying providers of particular mixes of services. Simple copying of foreign institutions or policies is not advisable.

The kind of (financial or other) support that might be called for from government in order to facilitate a particular kind of service supply depends on the content of the service and not simply on the institutional character of the supplying organisation. Different orders of 'stickiness' in knowledges and technologies (Figure 13□□) mean that policy must recognise and promote a mixed economy of innovation-services provision. For example, some 'unsticky' and 'free' supplies - such as basic science results - have high downstream complementary-competence costs before they can become part of a significant competence for user firms, and the total lifecycle cost of a significant competence must be assumed to be high: strategic competences are not cheap. Various kinds of governance in the delivery of services - short-term transactional relationships, longer-term business partnerships, medium-term pre-competitive 'learning' collaborations, etc - are required to facilitate different modes of competence supply to firms with differing existing structures of competences (eg small firms, hi-tech firms, niche-specialist firms, firms integrated into supply chains upstream of a demanding multinational supplier; and so on). A simple distinction between classically public and classically private forms of production, ownership and control fails to handle the significant span of modes in which service generate competences. It fails also to handle the governance of delivered service *outputs* (referred to in Figure 12□□ above as 'frames of service delivery') as distinct from the governance of assets and other inputs to the service-providing organisation (referred to in Figure 12□□ above as 'institutional governance').

In the belief that government (as a guardian of public goods) should adopt it too, RISE has chosen to adopt a firms-eye view of the diffuse and mixed system within which RTOs contribute their services, rather than a suppliers-eye view. From the point of view of a service-using firm involved in innovation, the entire system of innovation services (explicit and bundled, from consultancies and RTOs, etc) exists simply as a 'service manifold' to support its technology management and innovation processes over their whole span. Ideally these services might be accessed by a firm in an integrated way. However, a one-stop shop for the entire range of potential services related to innovation or technological competence is clearly impractical. More limited integrations of services into a discrete range of service products must be a more practical approach.

9 Facilitate changes in the service modes of RTOs

As represented in Figure 9 above, traditional RTOs which had an 'expert-to-expert' mode of cooperation with firms are involved in two trajectories of change: towards greater intensity of packaged 'client learning' content with firms whose technological capabilities are less highly developed, and towards services with greater 'asset transfer' content. As discussed in Appendix 7, government should facilitate both development processes through mechanisms including changes in the performance criteria associated with public funding and changes in the business models of RTOs involving various forms of commercialisation of activities.

10 Safeguard multiple roles of RTOs under other aspects of policy

RISE adopts a perspective exclusively focused on the development of innovation and competitiveness in national firms. Actual RTOs frequently carry additional non-innovation functions related to science, technology and medicine. The contingent historical mix of services means that RTOs - and rationales for funding RTOs - should be considered under other aspects of policy in addition to innovation and services direct to firms: these may include employment, local labour markets and labour relations, regional development, social exclusion and citizenship, cultural activities and general literacy, scientific advice to the public, inputs to political debate and decision making, forensic inputs to judicial processes and services to public infrastructures such as transport, health and energy.

In making changes to the funding of RTOs, government may be criticised for trying to sacrifice long-term public or cultural tasks on the altar of short-sighted responses to industry needs. Conflicts arise between roles (eg public funding for a public advice function may act as hidden subsidy to an industrial consultancy function; a reward system for scientific output may inhibit investment in services to small firms). Policy should be concerned not to reduce the functional diversity of the RTO population. More specifically, distortions and conflicts of interest should be monitored and remedied, regarding innovation-services markets (where the government is purchaser or funder) and impartial advice or information to public agencies (where RTOs as service-providers to firms or government clients may have entrenched departmental, sectoral or commercial commitments and interests). These need to be handled at the level of discrete business units of the RTO, and their relationships with each other (or perhaps by transferring functions to other organisations under different and more appropriate forms of governance).

Bibliography

AIRTO (2000). *Minister welcomes the contribution of AIRTO members to the development of a knowledge driven economy*. Press release, annual parliamentary lunch of AIRTO. AIRTO paper 2000/1. AIRTO, July 2000.

Backlund, A., Häggblad, H., Markusson, N., Norgren, L., & Sandström, A. (2000). *The Swedish biotechnology innovation system*. Internal report, RISE project workpackage 1, December 2000.

Bessant, J., & Rush, H. J. (1998). *Approaches to benchmarking - The case of 'framework conditions' and ICT-Os*. Report for CEC Joint Research Centre, Prospective Technological Studies. University of Brighton, Centre for Research in Innovation Management, February 1998.

Cook, S. D. N., & Brown, J. S. (1999). Bridging epistemologies - The generative dance between organizational knowledge and organizational knowing. *Organization Science*, 10(4), 381-400.

den Hertog, P., Brouwer, E., & Maltha, S. (2000). *Innovation in an adolescent cluster - The case of the Dutch multimedia cluster*. RISE project report. Dialogic, Utrecht, May 2000.

Dodgson, M., & Bessant, J. (1997). *Effective innovation policy - A new approach*. London: International Thomson Business Press.

Fontes, M. (2000). *The biotechnology cluster in Portugal*. report for RISE workpackage 1.DMS 014/2000). INETI, Lisboa, October 2000.

Hales, M. (2001). *Service deliveries in an economy of competence supply*. Final report, RISE workpackage 5.CENTRIM, University of Brighton, January 2001.

Hauknes, J. (2000a). *The service economy thesis*. RISE theme paper. STEP group, Oslo, December 2000.

Hauknes, J. (2000b). *The service society*. RISE theme paper. STEP group, Oslo, December 2000.

Hauknes, J., & Wicken, O. (1999). *Innovation policy in the post-war period - Trends and patterns* .STEP group, Oslo, December 1999.

Jacobs, D., & de Man, A.-P. (1996). Clusters, industrial policy and firm strategy - A menu approach. *Technology Analysis and Strategic Management*, 8(4), 425-437.

Koch, P. M., & Hauknes, J. (2000). *On policy learning and the interaction between policy makers and researchers*. Final report, RISE workpackage 4. STEP group, Oslo, November 2000.

Leonard-Barton, D. (1995). *The wellsprings of knowledge*. Boston MA: Harvard Business School Press.

Lipsey, R. (1998). Technology policies in neo-classical and structuralist-evolutionary models. *STI Review*, 22, 31-73.

Metcalfe, J. S., & Georghiou, L. (1998). Equilibrium and evolutionary foundations of technology policy. *STI Review*, 22, 75-100.

Norgren, L., & Hauknes, J. (1999). *Economic rationales of government involvement in innovation and the supply of innovation-related services*. RISE project report, chapter 3, literature review. NUTEK, Stockholm and STEP group, Oslo, June 1999.

Norgren, L., & Hauknes, J. (2000). *Economic rationales of government involvement in innovation and the supply of innovation-related services*. Final report, RISE workpackage 3. NUTEK, Technology Policy Studies, Stockholm and STEP, Oslo, November 2000.

OECD (1999a). *Benchmarking knowledge based economies*. OECD science, technology and industry scoreboard. DSTI/STP/TIP(99)). OECD,

OECD (1999b). *Boosting Innovation - The Cluster Approach* .Organisation for Economic Co-operation and Development: Paris, France,

Pavitt, K. (1984). Sectoral patterns of technical change - Towards a taxonomy and a theory. *Research Policy*, 13, 343-373.

Prahalad, C., & Hamel, G. (1990). The core competence of the corporation. *Harvard Business Review*, 68, 79-91.

Preissl, B. (2000a). *The innovation cluster of the German automotive components sector*. Internal report, RISE project workpackage 1.DIW - RISE working paper Nr.3. DIW, Berlin, January 2000.

Preissl, B. (2000b). *Research and technology institutes and the service economy - A functional perspective on innovation related services*. Final report, RISE workpackage 2.DIW Berlin, November 2000.

Readman, J. (2000). *The UK book publishing and printing cluster - Summary report*. Project report, RISE project workpackage 1. CENTRIM, University of Brighton, November 2000.

Rhodes, R. A. W. (2000). *The ESRC's Whitehall programme*. In. Vol. 2000, University of Newcastle, England.

SME Foresight (1996). *Adapting to new patterns of supply*. Foresight bulletin, available at <http://www.dur.ac.uk/~dbr0www>.4). Durham University Business School, Small Business Foresight research programme in association with NatWest Bank, 1996.

Smith, K. (1998). *System approaches to innovation - Some policy issues*. ISE report. Systems of Innovation Research Program, Department of Technology and Social Change, Linköping University,

Teece, D., & Pisano, G. (1994). The dynamic capabilities of firms - An introduction. *Industrial and Corporate Change*, 3(3), 537-556.

Teece, D. J. (1998). Capturing value from knowledge assets - The new economy, markets for know-how, and intangible assets. *California Mgmt Review*, 40(3), 55-79.

Teece, D. J., Pisano, G., & Shuen, A. (1990). *Firm capabilities, resources and the concept of strategy*. Consortium on Competitiveness and Cooperation Working Paper.90-8). University of California, Berkeley, CA, 1990.

Verbeek, H. (1999). *Innovation Clusters - Identification of value-adding production chains and their networks of innovation: An international study*. Masters thesis, Erasmus University, Rotterdam, The Netherlands.

Whalley, J., & den Hertog, P. (2000). *Clusters, innovation and RTOs - A synthesis of the findings from the RISE cluster studies*. Final report, RISE workpackage 1.Department of Management Science, University of Strathclyde, Glasgow, Scotland and Dialogic, Utrecht, The Netherlands, November 2000.

Winter, S. G. (1987). Knowledge and competence as strategic assets. In D. J. Teece (Ed.), *The competitive challenge - Strategies for industrial innovation and renewal* (pp. 159-184). Cambridge MA: Bullinger.

Wood, D. (1992). *The power of maps*. London: Routledge.