



Analyseinstitut for Forskning

**Dynamic Research Environments
- A Development Model**

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1. Introduction	5
1.1. Centres of Excellence	6
2. Emergence and development of research environments	7
2.1. Case examples of dynamic and innovative research environments	7
2.2. A development model of research environments	8
2.2.1. A development model	9
2.2.2. The studied research environments	14
3. Characteristics of dynamic and innovative research environments related to a theoretical framework	14
4. Preconditions for excellence in research environments	18
5. Conclusion	20
References	22

Abstract: The article outlines a model for the development of dynamic and innovative research environments in national innovation systems. The development model is based on an in-depth study and analysis of 15 research environments selected by the Danish Council for Research Policy as examples of dynamic and innovative public research environments. According to the model, research environments follow some stages with respect to epistemological, organisational, and socio-cultural development that either enable them to advance from one stage to the next in the model or impede this advancement. The consequence of the latter is either a static state or dissolution. In the long run only dynamic and innovative research environments survive. The analysis of the studied cases identifies several preconditions that have to be present in such research environments in order for them to emerge, develop, and finally reach excellence. The results presented here may well be a valid tool for policymakers, particularly in Europe where the framework conditions for public R&D are comparable to the Danish.

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1. Introduction

Research, development, and other innovation have been put forward as a top priority together with upgraded human resources in the development of knowledge-based economies. The aim in the European Union to build the European Research Area (ERA) in an efficient way has created a need for knowledge on how research environments work and which research environments that can be used as examples of best practice in a development process towards a well-functioning and efficient ERA. The present paper is based on an in-depth study and analysis of 15 research environments selected by the Danish Council for Research Policy as examples of dynamic and innovative public research environments, c.f. Graversen et al. (2002b).

The analysis identifies a number of common characteristics among these research environments, c.f. Graversen et al. (2002b). Together with the historical path of each research environments these characteristics has been used to identify a general development model of research environments. Lastly, the selected research environments has been used to identify the unique preconditions that make these well functioning and efficient research environments dynamic and innovative.¹ The preconditions have to be present in order to develop dynamic and innovative research environments further into centres of excellence.

Other aspects of dynamic and innovative research environments are discussed in Graversen et al. (2002a) and in Kalpazidou Schmidt et al. (2003) regarding research policy perspectives as well as in Kalpazidou Schmidt (2002) and Langberg (2003) regarding organisation and management in dynamic and innovative research environments.² Identification of the most effective and efficient framework conditions supporting existing and new public research environments becomes ever more important for policymakers in an attempt to create and maintain the necessary structures that secure a sufficient degree of research excellence in the national as well as in the European innovation system.³

Even though research policy initiatives may facilitate the creation and maintenance of new research environments, the initiatives and ideas have to emerge from existing resources in the innovation system, e.g. the existing researchers or research environments. Hence, the emergence, management, organisation, and development

¹ Naturally, some of the common characteristics also end up as preconditions, e.g. openness, strategic planning, research competent management, or highly motivated researchers.

² See also Ziman (1994), Benner and Sandström (2000), Becher (1989) and Clark (1987) among others as general references on these aspects of research environments.

³ The national or regional politicians may be more oriented to create framework structures that support local based R&D and secure that it stays local. Hence, a European synergy effect may emerge if the regional policy making becomes more coordinated and interacted with the ERA research objectives.

of research environments are as vital as the political and economical infrastructure surrounding it. The one part requires the other in order for the interaction to give optimal results for the knowledge-based economies.

1.1. Centres of Excellence

Recent policy initiatives have focused on the emergence of Centres of Excellence as a way to reach the research aim of a European Research Area, c.f. European Commission (2000). Centres of Excellence are defined in the present paper as research environments that produce research of the highest international quality.

Improving the quality of research centres is seen as the main factor in developing the ERA. While this is clearly important, the present analysis identifies dynamism in the entire innovation system that fosters the steady and continuous development of promising new research area into centres of excellence. Whether this potential is materialised as centres of excellence capable of producing research of the highest quality depends on the structural framework and the ability to adapt to changes.

The construction of a well functioning ERA depends highly on the national frameworks and structures for research, external funding possibilities, and also on internal factors in the research environment such as skilful research management, visionary managers and creative researchers. Hence, the bottom-up emergence of research environments requires sufficient structural external support in order for them to develop to centres of excellence. Narrowly targeted national research programmes may result in centres of excellence in the targeted areas, but this may nevertheless be less efficient and may have smaller societal impact in the long run. In stead, better broad structural conditions for these and other areas will benefit in the emergence of (more) centres of excellence in several areas, including the targeted, to the benefit of the entire national innovation system. Better knowledge concerning the best suitable research policy that enables these structures to be present is a first step towards an innovations system with centres of excellence, c.f. Koch et al. (2003).

This article presents the case examples of dynamic and innovative research environments in section 2.1 and uses these to identify common stages in a general development model for research environments in section 2.2. Section 3 outlines the common characteristics of the selected research environments that are attributed to both internal and external factors in the environments as well as interactions of these. Furthermore, the characteristics are related to the concept of rural and urban research environments developed by Kalpazidou Schmidt (1996). The studied cases show characteristics of the urban research environments. Section 4 summarises the common characteristics and the necessary preconditions for excellence in research

environment. The preconditions for development of research environments to centres of excellence concern organisation and leadership, framework and structures, and resource allocation. Section 5 concludes the paper.

2. Emergence and development of research environments

Open-minded yet focused on ideas that require full attention and epistemological research can best describe developing research environments, c.f. Graversen et al. (2002a). Allowing new ideas to emerge, networking and exchanging of ideas with other environments and internal and external cooperation secures that research environments develop over time giving the basis for the achievement of excellence in research. The analysis of the studied research environments provided a number of benchmarks for dynamic and innovative research environments. These benchmarks and other common characteristics were used in the analysis to identify a common model for the development of research environments. The model has as a point of departure the origin of research environments and follows different stages of development to centres of excellence. The model is general enough to apply to all types of research environments.

According to the model, closed and static research environments will only develop slowly and be less dynamic than other research environments. In the medium to long run they will be less innovative and cease to exist due to lack of funding in an innovation system based on funding competition.⁴ Hence, without renewal and development of ideas and knowledge, such research environments will degenerate and disappear over time.

2.1. Case examples of dynamic and innovative research environments

The empirical cases that make up the data material were collected and used in a study by the Danish Institute for Studies in Research and Research Policy (AFSK) in autumn, 2001. On initiation by the Danish Council for Research Policy, AFSK analysed the cases and presented a series of structural and process related conclusions regarding common characteristics of dynamic and innovative research environments, c.f. Graversen et al. (2002a). The Danish Council for Research Policy has chosen the empirical cases based on advisory work in connection with the activities of the Danish Research Councils.

The studied research environments represent all fields of science and physical or non-physical institutional frameworks. The cases represent various administrative

⁴ The policy trend in Denmark as well as in the ERA goes in the direction of higher funding competition among the research environments. Among the criteria for future funding that are becoming increasingly important are societal relevance, industry-science cooperation and external co-funding rates.

and organisational types of research environments, such as university departments, governmental research institutions, research centres, or departments of existing research environments. The cases consist of newly established as well as old well-established research environments. The research environments have between five and 200 researchers employed or affiliated and their existence varies between one and 15 years in the present organisational form. However, a few of the research environments have been active in different organisational structures for more than 40 years.

The research environments have typically been created as a consequence of the development of a new idea, a new theme or the renewal of an existing field. However, the research environments are not identical regarding age, size, organisation, structural form, frame or origin. Despite the differences, the analysis identifies a common structure in their development over time. Some common initial conditions have been present to secure the spin off of the research environments and other internal and external conditions have been present to secure their survival and development over time towards centres of excellence, c.f. section 2.2.

The analysis of the 15 research environments reveals some common characteristics for dynamic and innovative research environments. These characteristics concern the emergence, management, organisation, funding, and development of the research environments. A summary of these features is outlined in table 1 in section 3. The main conclusion is that dynamic and innovative research environments clearly have a common point of departure, use strategic planning, and have well-defined goals but also that they fundamentally rely on a solid and acknowledged research base.

2.2. A development model of research environments

The findings in the analysis were used to identify groups of research environments with a significant amount of common characteristics that could be used to gather them into common clusters. Furthermore, the clusters of research environments could, after a more detailed analysis, be linked in a unique model for research environments where the groups were fitted into different time development stages. The clusters fit in at the upper stages in the model that show how research environments emerge, develop, become dynamic and innovative and not least when they perform excellent research, c.f. tables 1 and 2.⁵

⁵ There were natural dissimilarities between the research environments; dissimilarities that were specifically related to scientific field, policy or person dependent circumstances that do not contribute to the common characteristics and the general development model.

The identified development model will be outlined in the following. As the discussion will underline, the model can be seen as a general development model for research environments. This means that the development model is general enough to fit many different kinds of research environments, i.e. also research environments not included among the empirical cases and independent of whether they are dynamic, innovative or neither of these. All the studied innovative and dynamic research environments fit in at the upper stages in the model where they all have passed the stages below and have qualified to be judged as dynamic and innovative, c.f. tables 1 and 2.

2.2.1. A development model

Table 1 illustrates the stages in a general representative research environment's development towards excellence. The common features in the development among the 15 studied research environments have given the basis for a model for how and at what speed research environments emerge, develop, change, and reorganise in a continuous dynamic process. The time dimension may vary for each research environment, meaning that the stages are passed faster or slower for some research environments than for others.

The model follows a development track starting at stage one and continuing up to the excellence stage as illustrated in table 1. The historical path of the studied research environments has been used to identify the lower stages in the development model. The dynamic and innovative research environments have all been through these earlier stages. At all the stages the research environments have been further developed based on a high quality research foundation. A clear and visible focus on research productivity, research quality, and competence development characterise the dynamic and innovative research environments on all the stages in their development. However, this may not in general be the case for research environments at the earlier stages in the model. If it is not the case, these latter research environments will at a lower stage in the model cease to develop and become static or close down.

At the first **initial stage** in the model, the "material" that makes or initiates the emergence of the research environments is found; c.f. table 1 and table 2. These original initiators may be in the form of external pressure on existing research environments, for example a university department or an institute that is threatened by closing due to poor research production, organisation or management problems. Another initiator is fiery souls, who through an enormous engagement and high research capability establish the basis for a new research area. These initiators may typically through external funding over time establish an informal research group or centre. Yet another initiator is found in transdisciplinarity, i.e. parts of existing

research fields that become self-standing disciplines. Related research environments may become so visible that it seems natural to establish a group based on existing transdisciplinary networks, like for example nano-science in recent years. Common for the different initiators is a visionary research based plan for the next move to the **planning stage** in the development model.

The vision or visionary plan for a research environment typically requires the existence of an informal group or network consisting of like-minded researchers before it can continue. On the **1st generation** stage there often is a very visible natural leader, who by engagement, expert knowledge, reputation and/or management abilities secures that the environment as well becomes visible, gets financial support, and gathers the necessary research expertise. Having these aspects present allows the informal group to perform research output supporting its existence and further development towards the **2nd generation** stage where they become a formal and established research group, centre or unit. It is first at this stage that the research environments are recognised as real and formal research environments that can be referred to as such.

Table 1. A development model for research environments

Development stage	Characteristics of each stage
Initial stage	External pressure Fiery soul(s) Critical mass
↓	↘ ↓ ↙
Planning	Vision or plan is implemented
↓	↓
1 st generation	Informal group or network is built
↓	↓
2 nd generation	Research environment is formally established
↓	↓
3 rd generation	Reorganise to meet change in conditions
↓ ↑	↓ ↑
Consolidation	Excellent research output Specialise and consolidate
↓ ↑	↓ ↑
4 th generation	Consolidate Excellence Reorganise to meet changes in conditions Become Centres of Excellence

Note: The arrows illustrate the research environments' development possibilities between the stages. This implies that they can either advance to the next stage or decline. See also table 2.

After the formal establishment as a 2nd generation research environment it is the reorganisation of the research environment and consolidation of the research quality and production that becomes the most important issue for the medium to long run survival of the environment. Typically, the first reorganisation of the research environment is the most difficult including the largest risk of failure. A research environment that has passed its first major reorganisation has moved over to be a **3rd generation** research environment. The reorganisation at this point in order to be a 3rd generation environment often implies an academic or structural reorganisation to new or changed internal as well as external conditions such as professional, epistemological, economical or structural changes. At this stage it may become clear that the initial and original manager or research leader that started the process might have been a skilful developer but not a similar good consolidator or research administrator. In such cases the first reorganisation also requires a shift of manager, management style or research strategy.

Given that the research environment survives the establishment phases and the first reorganisation, their next hurdle to overcome is to reach the top academic level where they produce excellent research in a continuous steady flow. This

consolidation stage includes organisational focus on objectives such as renewal, innovation, reorganisation, and excellent research outcomes that match the scientific purpose. Passing the consolidation stage with success characterises the **4th generation** research environment meaning that the initial stage vision to create an excellent research environment in the field has succeeded, although usually in a reformed version. For the research environments, the challenge becomes to remain at the top or keep their position as **centres of excellence** in the field through a continuous epistemological, organisational, and socio-cultural development of the research environment in order to adapt the organisation to internal as well as external changes.

Table 2. The dynamism at each stage in the development of research environments towards the level of excellence

Stage	Dynamism at each stage
Initial stage	Either an external pressure, a fiery soul or a critical mass of researchers initiates the start for the creation of a research environment
↓	The vision or plan circulates in the existing research system
Planning	The vision or plan gets support from a group, the management or an internal or external financial source
↓	The vision or plan gathers an official group of researchers around a common research area or subject
1 st generation	The research group focuses on a specific research field and uses eventual financial support to form the group of researchers and research expertise
↓	The research group strengthens their standing through quality research that can justify support for creation of a formal research group
2 nd generation	The research group is reshaped as a research environment such as a centre, a department or a research unit
↓	The research environment strengthens professionally and organisationally. The original research objectives develop further and become the basis for the environment
3 rd generation	The research environment is reorganised based on the original research aims and focuses on dynamism and innovation
↓ ↑	The research environment raises the research quality to excellence levels
Consolidation	The research environment performs excellence research on an international level because it has succeeded in renewing, developing, and consolidating their research in a dynamic organisation
↓ ↑	The excellent research quality is retained by a dynamic and innovative research environment
4 th generation	The research environment produces excellence. It is reorganised, renewed, and developed in a continuous process where the aim is to retain and support the excellent position in the international research system

Note: The arrows illustrate the research environments' development possibilities between the stages. This implies that they can either advance to the next stage or decline. See also table 1.

Passing some stages does not ensure that a research environment will finally reach an excellence level or remain at such a level, i.e. become a 4th generation research environment as shown in tables 1 and 2. At the same time it cannot be taken as given that a research environment will remain at the excellence level once it has reached it. According to the model, research environments exist on a given stage as long as it is legitimated by research quality, research policymaking or funding. Along the common development track research environments emerge, develop, and consolidate or fail to do so over time by various reasons.

Research environments not fulfilling the requirement to climb to higher stages become static or degenerate and disappear in the long run, i.e. close or dissolve. Consequently, research environments can in any stage be closed if they cannot respond to the internal or external requirements.⁶ If the research environments fail on any of the first five stages they disappear in their present form. They may continue in form of some other constellation, but in such a case this is a new research environment starting up again at the initial stage, or they can be transformed to a teaching unit conveying knowledge or advising, meaning that they disappear as a research environment. At the consolidation and 4th generation stage the research environments can periodically step backwards in their development, lowering the ambitions and/or research quality and/or outcome. The double arrows between the three upper stages in the model mark this option. This means that a research environment can fail with regard to research excellence in a period and fall a stage or two in the development model but continue to exist (at the 3rd generation or consolidating stage) and regain the excellence 4th generation stage after a period or fail at the 3rd generation stage and close down as an independent research unit and disappear. Hence, the terms 4th and 3rd generation mark a development stage and not an age dependent stage.

However, most research environments are not static but continuously developing and reorganising units that exist as long as their research and common internal and external interests justify it. In cases with large changes where part of the original research environment better fits into a new unit at or below the 2nd generation stage, a new research environment may emerge as a spin-off from an existing environment. It is important in this context to keep in mind that the stages are relative to the units meaning that some research environments can remain at a certain stage for a (very) long period while others pass it fast and smoothly, almost as jumping over the stage.

⁶ The model can also be seen as a general survival model of research environments where the generality in the model is secured through a closing possibility at each of the lower stages.

2.2.2. The studied research environments

The 15 research environments in the case study can all be placed at one of the upper stages in the development model scheduled in table 1. They have all survived the first critical stages and their historical development track illustrates that research environments that reach the 2nd generation stage with the formal group creation, considerably increase their further survival probability. The research environments in the case study are all well-established environments that work on justifying their existence through reorganisation, research consolidation, development, and innovation in order to secure their position in the Danish (and global) innovation system.⁷

Two groups of research environments are in their first organisation or reorganisation stage trying to match the actual research framework and conditions and developing the quality of their outcome. Another group of research environments have passed this stage and are consolidating their research position as a dynamic research environment in the national innovation system. Lastly, a third group of research environments out of the 15 studied research environments can actually be characterised as 4th generation research environments. They have a stable and solid production of excellent research and are already centres of excellence.

3. Characteristics of dynamic and innovative research environments related to a theoretical framework

An in-depth analysis of the case examples of dynamic and innovative research environments revealed a number of common characteristics of these research environments, c.f. Graversen et al. (2002b). Firstly, the characteristics were identified as internal and external to the environments factors, c.f. table 3 and secondly, compared to definition of factors characterising rural and urban research environments, c.f. Kalpazidou Schmidt (1996).

A theoretical framework that differentiates internal and external factors or framework conditions for research environments is based on two perspectives in the literature, i.e. the “internalist” and “externalist”.⁸ According to the internalist perspective, internal to the environments factors such as leadership, researchers, and epistemological issues within the research environment solely determine the research environments’ dynamics. In the externalist perspective these determinants are influenced by external factors as well. These external factors are for example the research policy

⁷ The placement of the research environments on the upper stages in the model is based on the analysis of the research environments’ performance and historical evolution together with the written material from the Danish Research Councils and the Danish Council for Research Policy.

⁸ See Kalpazidou Schmidt et al. (2003), Kalpazidou Schmidt (1996, 2002) and Foss Hansen (1988) for a comprehensive discussion of the interrelation between these two theoretical perspectives.

influencing research framework or research infrastructure and also determinants based on human capital investments, organisational structure etc.

However, these latter determinants can indirectly be included in the broader research framework conditions. As also concluded in Kalpazidou Schmidt et al. (2003) the two perspectives are best seen as complementary as the empirical analysis of the influence of research policy also confirms. As a consequence Kalpazidou Schmidt (1996) developed an approach that combined the two analytical perspectives in a model for studies of research environments (MSRE), c.f. Kalpazidou Schmidt et al. (2003). The present study has as a starting point this approach that identifies the necessary preconditions for the emergence as well as development of research environments and the characteristics that result in centres of excellence that policymakers and others aim to, c.f. also the ERA proclamation.

The characteristics of the studied research environments are as mentioned above summarised in terms of internal and external factors, c.f. table 3. The characteristics will only be briefly commented here, but a general observation is that the studied research environments are very active on several areas from management over high quality research to work climate among researchers.⁹ Among the internal factors identified in the research environments are factors concerning the management and leadership of research environments. Other internal factors concern the research strategy and objectives, open-mindedness for external inspiration, human resource management, and social and working climate. The external characteristics concern the frameworks that the research environment exists in. The factors are funding conditions, receptiveness with regards to external changes such as research policy initiatives, but also societal visibility, and industry-science interactions, c.f. table 3.

The studied research environments all rely on virtues like independent academic research, competence, and reputation. These virtues are successfully managed through competent leadership and the research has clear societal relevance. However, it is still important to notice that all the characteristics concerning the studied research environments are based on a foundation of research quality that is the initial precondition for all activities and development.

⁹ For a comprehensive discussion of the urban and rural characteristics see Kalpazidou Schmidt (1996, 2002).

Table 3. Characteristics of dynamic and innovative research environments

Common internal characteristics

- The research environments:
 - Have active, transparent and research competent leadership
 - Are based on modern personnel management with adequate leadership qualities
 - Have active leaders within the research environment, in relation to the political system and to the society in general
 - Focus on organizational efficiency and research productivity

 - The research environments have clear and visible research strategies and objectives that are mainly formulated by the management through:
 - Planning and coordination of activities, defining research target areas
 - Prioritisation among research areas and projects
 - Focus on research quality and competence development

 - The research environments are often shaped against the backdrop of inspiration from abroad regarding:
 - Physical planning and organization of research
 - Choice of research field and subjects
 - Interactions through networks and other knowledge transfer media

 - The research environments have a well-defined and transparent human resource management profile:
 - The researchers justify the managers right-to-manage in the strong research competence among the managers
 - Staff policies are based on the principles of research autonomy (especially during the research process)
 - The management profile support a scientific elite and create excellence quality
 - The clear recruitment policy built on core senior competences

 - The research environments have a good working climate:
 - Based on internalised norms and research traditions
 - Show openness towards new ideas, methods, and traditions in an ongoing dialogue
-

Common external characteristics

- The research frameworks are excellent regarding:
 - Funding
 - Substantial external funding
 - Receptiveness to changes in research policies and academia labour market

 - The research environments have flexible organisation structures:
 - High ability to adapt to external factors and receptiveness to structural changes
 - Promote own research interests in the surrounding society
 - Good connections to private sector and political establishment

 - The research environments work in areas that have societal relevance
 - Combine societal demands with professional interests of the group
-

Source: Common characteristics summarised from Kalpazidou et al. (2003) and Graversen et al. (2002a).

The analysis of the studied research environments also revealed that such environments were primarily urban in their character, c.f. Kalpazidou Schmidt (1996) where she introduces the concept of urban versus rural research environments to describe the organisation and internal culture in research environments.¹⁰ The overall context for **characteristics of the studied research environments and the urban research culture** can be summarised on the following four features:

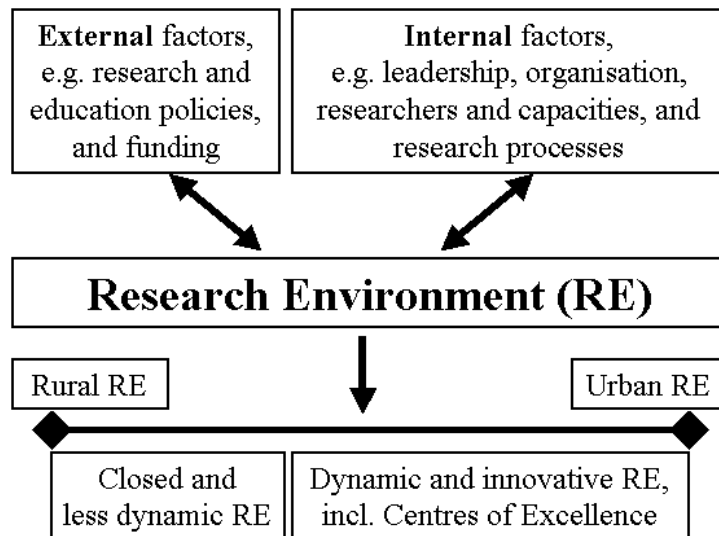
- **Input:** The studied research environments have, as urban research environments, considerably larger amounts of external funding and are based on a competence that contains different generations of researchers.
- **Organisation:** The studied research environments have a hierarchical organisational structure (urban) opposed to a flat structure (rural). The studied research environments also have a considerably higher degree of research prioritisation and coordination as well as a clear research strategy.
- **Research process:** Just as urban research environments, the studied research environments are based on teamwork, and have a well defined, narrow ranged, focused, and often positivistic research profile. Researchers have limited choice of areas or subjects but enjoy autonomy during research processes. The studied research environments have an intensive internal professional and social dialogue, a high external visibility, intensive networking, show high researcher mobility, and a high flexibility towards changes in external conditions.
- **Outcome:** Compared to other research environments, the studied research environments have a larger number of postgraduate students, and produce more doctoral dissertations and articles, the majority of which are internationally oriented. Moreover, production per researcher, in terms of publications, is also higher than in rural environments.

A comprehensive illustration of the ecology of the rural and urban type of research environments is given by Kalpazidou Schmidt (2002).

The interactions and links in the concepts of external and internal factors as well as urban and rural research environments are illustrated in figure 1. The external and internal factors interact with the research environment in a dynamic development and adjustment. The process and the outcome from the research environment defines whether it can be characterised as rural or urban, i.e. closed and little dynamism or highly dynamic and innovative research environment. Centres of excellence are found to be placed in the latter group, c.f. the discussion in section 4.

¹⁰ The concept was used to compare the ecology, organisation and research culture of research environments to a stringent theoretical model for such items, c.f. Kalpazidou Schmidt (2002). Research environments can be placed on a continuum from having a unique rural culture to having a unique urban culture. Most research environments will be placed somewhere in between, having some characteristics from both cultures, although typically most characteristics from either the rural or urban culture, i.e. they can be uniquely categorised.

Figure 1. Factors interacting with the emergence and development of research environments and the characteristics of the subgroups of centres of excellence



4. Preconditions for excellence in research environments

At the research policy level the study that this article is based on can be used to increase the relevant knowledge such that it becomes possible to identify, and build (or rebuild) the infrastructure that best supports the emergence and development of dynamic and innovative research environments in order to obtain research excellence. The appropriate structures will then be used to intensify the efforts to increase both the quantity and quality of research at the national as well as for the European innovation system.

The development model identified in section 2 together with the concepts of internal and external characteristics and urban versus rural research environments in section 3 can be used in this context to relate the necessary research infrastructure to build up such dynamic, innovative research environments, c.f. figure 1. From the results found some necessary preconditions for establishing dynamic and innovative research environments can be derived, c.f. table 4. The findings can be used in policy recommendations among others. The preconditions are described in three groups, namely organisation and leadership, framework and structures and finally resource allocation.

Building on the analysis of the findings in the two previous sections, dynamic and innovative research environments with a high quality research base, may with a relatively high probability develop to centres of excellence when the characteristics shown in table 4 are present. Furthermore, it seems likely that the concept of urban research environments also can be used to identify research environments with the capacity and ability to become centres of excellence.

It seems necessary for research environments to be flexible and open-minded to survive and develop in the medium to long run. Combined with a strong research-minded leadership, this flexibility allows the research environment to prioritize, reorganise, and cooperate whenever necessary to adapt into the changing framework. However, some framework conditions are better serving some research environments than others. Depending on the stage that a research environment is on, different frameworks and conditions for research seems to be optimal for it. This underlines the necessity to have differentiated national frameworks that best suit the various needs. This can for example be in the form of differentiated funding of research among environments and fields, for example such that basic research gets a higher share of initial public funding compared to applied research that have higher success rates due to its immediate user orientation, that makes it better able to attract external funding.

Table 4. Necessary preconditions that enable dynamic and innovative research environments to become centres of excellence

Organisation and leadership
<ul style="list-style-type: none"> • Flexible and open-minded; intensive internal and external communication
<ul style="list-style-type: none"> • Operational research management with possibilities to change strategies and research targets; adapting to external changes, prioritize resources and recruit talents
<ul style="list-style-type: none"> • Ensure that the private corporate sector is sufficiently aware and informed regarding possibilities and perspectives in cooperative research with public sector research environments
<ul style="list-style-type: none"> • Intensified and high prioritisation of external dialogue and cooperation with other national and international research environments, establishing of networks as well as exchanging of researchers
Framework and structures
<ul style="list-style-type: none"> • Differentiated frameworks and conditions for research requirements as well as research environments
<ul style="list-style-type: none"> • Strengthened organisational development of research environments built on local knowledge of research conditions and needs
<ul style="list-style-type: none"> • Organisations that allow emergence of new research constellations as a way to ensure innovation and increase interdisciplinary activities
<ul style="list-style-type: none"> • Time and resources given to research leaders to ensure that they are able to efficiently implement the research strategies; upgrading of management skills among the leaders as an integrated part of organisation development
Resource allocation
<ul style="list-style-type: none"> • Funding types shall vary between different research environments and fields; Basic research requires more initial public funding while the resulting research has higher success rates for external funding due to its immediate user orientation
<ul style="list-style-type: none"> • Research environments shall introduce better and varying types of incentives among the researchers to promote the research efficiency and productivity
<ul style="list-style-type: none"> • Research policy shall differentiate in the funding of well-defined paradigms and new paradigms that are not yet well-defined; The first can have prioritised research fields while the second needs more scope and research freedom regarding choice of research items, funding as well as research productivity

Note: See Kalpazidou Schmidt (2002) and Kalpazidou Schmidt et al. (2003) for a comprehensive discussion of these conditions regarding research policy as well as organisation and management.

The main preconditions for dynamic and innovative research environments seem to be managerial flexibility, communication, and networking, differentiated framework conditions, and funding possibilities as well as differentiated research policymaking. Basically, there is a necessity for broad, stable, and well-known structural frameworks that suit both the reorganisation of existing research environments and the emergence of new research environments. For example, it is necessary to differentiate between public funding to basic research or research in less developed paradigms and to applied research, c.f. table 4.

5. Conclusion

The purpose of the study this article is based on has been to identify aspects to be used to intensify the efforts of developing more and better research environments in order to achieve research excellence and increase economic growth in the medium to long run. A sample of dynamic and innovative research environments has been used as cases to identify the common characteristics that influence their development up to their present stage and research status. These dynamic and innovative research environments were examples of already existing centres of excellence or environments that could become such over time. The study illustrates that common characteristics of the dynamic and innovative research environments can be found internally in the environments as well as in the external research framework. This implies that both sets of characteristics have to be present simultaneously before public dynamic and innovative research environments emerge in the innovation system.

The study identified significant amount of similarities among the empirical cases that made it possible to outline a common development model for the dynamic and innovative research environments. The model contains all types of research environments, although the more static types disappear after some time opposite to the dynamic and innovative that survive in the long run. However, the emergence of research environments has its common origin in fiery souls, critical scientific mass or significant external pressure, no matter whether the research environment later becomes a steady centre of excellence or disappears again.

In the modelling of the dynamic and innovative research environments another common feature was identified, namely that they possess a common cultural and organisational setting that best fits the characteristics that defines urban research environments, c.f. Kalpazidou Schmidt (1996). The dynamic and innovative research environments were open, interactive, transparent, well organised in teams with strategic planning and were productive; all aspects that characterise the urban research culture. Hence, the characteristics of urban research environments seem to

be preconditions for developing dynamic and innovative research environments as well as centres of excellence.

Similarly, a combined model of the internalist and externalist perspective defined in section 3 best described the case studies. Front or top research environments are influenced by external factors too, such as the research policy determined research framework. Similarly, they work systematically to influence these external factors. Hence, a necessary precondition for the emergence and development of well-functioning research environments seems to be an interactive and pragmatic relation to the surrounding innovation system.

All in all, the present analysis has identified epistemological, structural, and organisational as well as cultural factors that need to be present in order to facilitate the development of dynamic and innovative research environments hereby creating a significant stock of centres of excellence in the national innovation system. Due to their generality and reliability, the results may very well be valid for policy recommendations world wide, although probably first and foremost in (western) Europe where the framework conditions for public R&D environments are more similar to the Danish framework conditions than it is the case for other parts of the world.

References

- Becher T. 1989. *Academic Tribes and Territories. Intellectually inquiry and the cultures of disciplines*. Open University Press. Stony Stratford.
- Benner M. and U. Sandström. 2000. *Inertia and change in Scandinavian public-sector research systems: the case of biotechnology*. Science and Public Policy. Vol. 27, no. 6,
- Clark B. R. 1987. *The Academic Life*. Princeton University Press, Princeton.
- European Commission. 2000. *Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions. Making a reality of the European Research Area: Guidelines for the EU research activities (2002-2006)*. COM(2000) 612 final.
- Foss Hansen, Hanne. 1988. *Organisation and control of research. An introduction to research on research*. Politik og Administration. Nyt fra Samfundsvidenskaberne. København.
- Graversen, Ebbe Krogh, Evanthia Kalpazidou Schmidt, Kamma Langberg and Per Stig Lauridsen. 2002a. *Dynamik og fornyelse på danske universiteter og sektorforskningsinstitutioner. En analyse af hvad der karakteriserer dynamiske og fornyende forskningsmiljøer*. The Danish Institute for Studies in Research and Research Policy. Report 2002/1. (In Danish).
- Graversen, Ebbe Krogh, Evanthia Kalpazidou Schmidt, Kamma Langberg and Per Stig Lauridsen. 2002b. *Dynamism and Innovation at Danish universities and sector research institutions. An analysis of common characteristics in dynamic and innovative research environments. English Summary*. The Danish Institute for Studies in Research and Research Policy.
- Kalpazidou Schmidt, Evanthia, Ebbe Krogh Graversen and Kamma Langberg. 2003. *Innovation and dynamics in public research environments in Denmark – a research-policy perspective*. Science and Public Policy, Vol. 30, No. 2.
- Kalpazidou Schmidt, Evanthia. 1996. *Research Environments in a Nordic Perspective. A Comparative Study in Ecology and Scientific Productivity*. Acta Universitatis Upsaliensis. Uppsala Studies in Education 67.
- Kalpazidou Schmidt, Evanthia. 2002. *Organization and Management of Research Environments*. The Danish Institute for Studies in Research and Research Policy. Working Paper 2002/11.
- Koch, Per, Lennart Norgren and Juha Oksanen. 2003. *GoodNIP – Good Practices in Nordic Innovation Policies. Part 1: Summary and Policy Recommendations*. STEP Report 06/2003.
- Langberg, Kamma. 2003. *Changes in Research Management at Danish Universities and Government Research Institutes*. The Danish Institute for Studies in Research and Research Policy. Report 2003/4.
- Ziman J. 1994. *Prometheus bound – science in a dynamic steady state*. University Press, Cambridge.