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Project co-ordinator:
Institute for Science and Technology Studies (IWT)/
University of Bielefeld
Universitätsstrasse 25, 33615 Bielefeld, Germany

Partners:
University of Surrey
Centre for Research on Simulation in the Social Sciences
Guildford GU2 5 XH, United Kingdom

Maastricht Economic Research Institute on Innovation & Technology
6200 LM Maastricht, The Netherlands

Institut National de la Recherche Agronomique,
Unité d'Economie et Sociologie Rurales
38040 Grenoble, France

Joint Research Centre of the European Commission
Institute for Prospective Technological Studies
41092 Sevilla, Spain

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Abstract

As an empirical observation it can be maintained with some justification that Innovation Networks play an important role within processes of societal modernisation in nearly all parts of society. Especially in the area of economy, innovation networks play an increasingly important role as regards the development of new products and their implementation in the market. Economic success and its benefits - decreasing unemployment and increasing public welfare as an example – depend on this new form of co-ordination of economic processes. Yet very little is known about innovation networks. Open questions are: What characterises an innovation network in comparison with classical forms of organisations? What is the structure of an innovation network, what are its elements, what are their basic interactions, what co-ordination mechanisms are important and what dynamics emerge from internal interactions? What is the relationship between an innovation network and its environment and how does the environment influence the dynamics of it?

The SEIN project was designed to produce answers to these questions. On the basis of empirical case studies on specific innovation networks in different fields like e-commerce, biotechnology, mobile communication and energy technology, empirical knowledge about the structure and dynamics of innovation networks was obtained.

On the basis of the empirical study as well as the concept of self-organisation, a theoretical model of innovation networks has been developed and was used to develop a computer simulation model. This General Simulation Model (GenSEIN) is a multi-agent model which animates the successful exploitation of innovation ideas. It makes it possible to analyse the influences of the different behaviour of agents (elements of the networks) and changes within the networks' environment on macro phenomena like network-formation and network-performance. It also makes it possible to study the role of different strategies of learning within and the supporting of innovation networks. Differences between "conservative" or "revolutionary" forms of partner search strategies can also be analysed. The first aims to look for partners who are very similar, the latter to look for partners who are as different as possible.

The General Simulation Model has been used to develop a new evaluation tool which concentrates on the comparison of innovation networks and concentrates on their performance instead of their output. It makes it possible to clarify where networks differ and where they share commonalities and/or focus on similar issues of relevance.

Summary Report
(Günter Küppers, Co-ordinator)

Science and technology policy should rely on an ever better understanding of processes of scientific and technological knowledge creation, technical change and innovation. This report aims at drawing lessons for policy from the improved understanding of innovation networks, their shapes, their dynamics, their structures, functions and performance characteristics. This improved understanding has been the aim of the project SEIN (Simulating Self-Organising Innovation Networks) which is presented more analytically in a book edited by Andreas Pyka and Günter Küppers under the title "Innovation Networks: Theory and Practice", published by Edward Elgar, Surrey in 2002.

This report consists of a synoptic presentation of the analytical framework of project SEIN , the case study material, the modelling and simulation work which lead to the development of a computer-based tool for the evaluation of science and technology policy options. Whilst the real life application of the tool may require further development, our improved understanding of networks of innovation provides a useful set of policy- relevant conclusions which are discussed in the final section.

1. Introduction

The term "knowledge society" has taken on an important role in public discourses in the last few years as an indicator of a fundamental change in society (Stehr 1994). Originally, the term was introduced by Fritz Machlup (1984) to mark the increasing importance of knowledge for economic progress. Knowledge is beginning to acquire the status of a resource like matter or energy. Bell (1973) goes even further and speaks about a revolutionary change from industrial to post-industrial society. His connotation offers a promise of modernisation with knowledge taking on the central role for societal progress. The production, distribution and use of knowledge characterises the new epoch and becomes the driving force for modern knowledge societies.

The literature on economic history has long used the term "science-based industries" to point to the exceptional importance of (scientific) knowledge in developing new processes and products. Even back in the second half of the 19th century, industrial progress, particularly in the chemical dye and electrical industries, was closely tied to the availability of scientific and technical knowledge, and this led to the emergence of industrial research. By the end of World War 2 at the latest, science had permeated all walks of life and has now become the major source of technological and societal innovation processes.

Nowadays, the competitiveness of modern companies depends decisively on access to the latest knowledge and its application in innovation processes. The provision and implementation of new knowledge has become the central challenge facing industry. This is acknowledged in the term "knowledge economy". "The problem of innovation is to process and convert information from diverse sources into useful knowledge about designing, making and selling new products and processes" (Freeman 1991: 501).

This increasing dependency of modern innovation processes on knowledge is only one aspect of contemporary economy. A second aspect of innovation dynamics is the fact that innovations are becoming increasingly more complex. The history of the development and manufacture of new products can be broken down roughly into three phases that are now juxtaposed, although they historically formed a temporal sequence. The first phase is the so-called craft production, in which highly skilled workers produce customised products for individual customers. The second is the development of mass manufacturing. Its characteristic is the division of a product into its component parts, which are standardised, thus allowing greater efficiency in production (Rycroft/Kash 1999). Since the second half of the last century a new, third phase has emerged characterised by the production of complex products, that is, products consisting of a increasing number of parts interrelated inseparably in a dynamic relationship. Compared with earlier motor vehicles for instance, "today's cars are complex sets of interacting automatic subsystems. For example, the fuel system has incrementally become an intricate linkage of sensors, microprocessors, and controls that govern the fuel injection process with such sensitivity that many young drivers have never known a car to cough and jump when it was cold. [....] 'The Ford Taurus has more computing power than the original Apollo that went to the moon [in 1969]'" (Rycroft/Kash 1999: 4).

Unlike the complexity of structures, in which the integration of various elements is treated as a pattern,[1] the concept of a dynamic complexity relates to a functional whole of a large number of interrelated processes or interactive elements. It is important to note that it is not the number of processes or elements involved which is the source of complexity. On the contrary, it is the quality of the linkage by which both the processes or elements are interwoven, allowing a new quality, i.e. a new function, to emerge. Therefore, a machine is not complex because it consists of various parts, but, at most, because it integrates the dynamics of these parts and unifies them in one function. It is precisely in this sense that modern products have become complex, as the example of fuel injection has shown.

Therefore, innovations are complex because

- new products integrate many elements into few functions,
- their production requires the integration of many resources within one organisation and
- their realisation needs the integration of many individual users into only a few contexts of applications.

In addition, modern technologies have to meet economic, political and social demands. In all, today's new products have to:

- Be economically viable. In other words, it has to be possible to develop and produce them with the available commercial resources. They have to be able to assert themselves on the market and they also have to make a profit.

[1] Measures of structural complexity are quantities such as entropy, redundancy, information and the like.

- Be technologically feasible. This means they have to function in technological terms while simultaneously being safe and reliable.
- Fit into the political landscape. In other words, they must not contravene existing environmental and safety standards.
- Be accepted by customers. This means they must fit into a real application context.

These functions cannot be met independently of each other. Changes to comply with technological safety may pose a risk to economic viability, new environmental standards may endanger technological functionality and technological specifications may threaten customer acceptance. Moreover, because of the functional unity, the whole cannot be broken down into its component problems and partial solutions cannot be integrated into a new product. Complexity requires an integrated, multidisciplinary approach. "This complexity has meant that multidisciplinary knowledge has become necessary for the generation and development of new products. In the computer industry, for example, the disciplines involved in the innovation process may range from solid state physics to mathematics, and from language theory to management science" (Malerba 1992). "So-called go-it-alone strategies or conservative strategies which mean that a firm relies only on its own R&D endeavours, cannot be successful in such a complex environment. Because of the systemic character of present-day technological solutions, technological development necessarily becomes a complex interactive process involving many different ideas, and their specific interrelationships" (Pyka / Saviotti 2000: 13).

As a new characteristics of this "new way of knowledge production" transdisciplinarity appears (see Gibbons et al. 1999). Network structures link the diverse knowledge of producers, suppliers and users located in different organisations in order to facilitate rapid exchange and decision making. "In this light networks represent a mechanism for innovation diffusion through collaboration and the interactive relationship becomes not only a co-ordination device to create resources, but an essential enabling factor of technical progress" (Zuscovitch / Justman 1995).

Thus, innovation networks emerge as a new form of organisation within knowledge production. Innovation networks are considered "to have three major implications: First, they are seen as an important co-ordination device enabling and supporting inter-firm learning by accelerating and supporting the diffusion of new technological know-how. Second, within innovation networks the exploitation of complementarities becomes possible, which is a crucial prerequisite to master modern technological solutions characterised by complexity and a multitude of involved knowledge fields. Thirdly, innovation networks constitute an organisational setting which opens the possibility of the exploration of synergies by the amalgamation of different technological competencies. By this, innovation processes are fed with new extensive technological opportunities which otherwise would not exist, or whose existence would at least be delayed" (Pyka 2000, 15).

Little is known about innovation networks. Open questions are: What characterises an innovation network in comparison with classical forms of organisations? What is the structure of an innovation network, what are its elements, what are their basic interactions, what co-ordination mechanisms are important and what dynamics emerge from internal interactions? What is the relationship between an innovation network and its environment and how does the environment influence its dynamics? To answer these questions the SEIN approach integrates two strategies: The empirical analysis of existing innovation networks in the fields of e-commerce, biotechnology, mobile communication and energy technology and the development of a general model of an innovation network on the basis of these case studies, which can be implemented as a computer simulation model.

2. The SEIN Case Studies

The different case studies analysed within the SEIN project were chosen with the aim of covering a wide variety of existing innovation networks. The subject of the case study on the Mobile VCE was a 'virtual centre of excellence' in the area of mobile and personal communications. It was set up in 1996, as a consortium involving seven UK universities and almost all the major European companies active in mobile communications. While Mobile VCE undoubtedly 'worked' according to the terms in which it was set up, this does not necessarily mean that VCEs are a useful policy tool. In comparison, another VCE for digital television technology, the Digital VCE, was very much less successful. In our conclusion, we summarise some of the specific issues relating to VCEs as a policy tool. We have found two sorts of alliance supported by Mobile VCE which are specific (though not necessarily unique) to VCEs as a funding mechanism and are of interest as a policy tool: the virtual links of the research network, and the self-perceived identity of the industrial network. The virtual research network in Mobile VCE encouraged inter-institutional work among research associates, as well as creating links between researchers and the industrial representatives involved in research management activities. The political aims of creating a virtual centre included the creation of a centre of excellence (by bringing together isolated research teams) and the encouragement of industrial-academic collaboration by providing industry with access to a wide range of the best academic work in relevant fields. Both these aims are better served by a VCE than by other policy initiatives aimed at forming research consortia. A VCE, it might be said, brings together two networks (the academic and the industrial), not merely individual actors.

Although Mobile VCE was largely judged a success, the VCE mechanism has not been reproduced beyond Mobile and Digital VCEs. One of the problems demonstrated by Digital VCE was the difficulty of identifying appropriate strategic sectors, where a critical mass of industrial interests could be enrolled in support of a virtual research centre. However, other industrial sectors might well be appropriate. The main problem for the future of the mechanism seems to lie in the broader selection environment, that is, the political priorities of the various funding agencies. The VCE mechanism may, for example, be held to offend against principles of competition – both in terms of encouraging competition between leading research teams, and in expecting the market (ie industrial funding) to take over from public funding. The latter was a concern of UK Engineering and Physical Sciences Research Council (EPSRC), for example, although it supported Mobile VCE's second three-year research programme. On the other hand, European funding priorities emphasise support for industrial development as the output of collaborative research projects: Mobile VCE offends against this, in that it has relied on being at least marginally pre-competitive in order to win the combined support of a competitive industry.

In the so-called biotechnology-based innovation sectors a high frequency of cooperative agreements has been observed since the end of the 70s. The main actors in these industries are large diversified firms (LDFs) with large shares of already established markets and dedicated biotechnology firms (DBFs), usually young start-up companies and university spin-offs with a strong knowledge base in the fields of biotechnology, as well as public research institutes and university laboratories. The asymmetric distribution of economic and technological capabilities and competencies is considered an important reason for early cooperative R&D efforts. Almost twenty years after biotechnology becoming a widely applied technology, already established large diversified firms have developed considerable competencies and capabilities, and some of the dedicated biotechnology firms have become large companies with several thousand employees and a considerable economic power. Despite these developments there is still an ongoing trend in cooperation. Accordingly, the motives for engaging in networks have changed from the so-called complementary assets to the exploration of a broader range of the research horizon using innovation networks as an extended workbench in R&D.

For a better understanding of these developments a simulation model of the evolution of innovation networks was set up. As it is an applied simulation exercise focusing on working out developments of a concrete sector, in the conceptualisation of the model much emphasis is placed on the characteristic features of this industry. Obviously the implementation of the model sketched here in the sense of a history friendly model was not an easy endeavour. The first step therefore was to analyse a prototypical case which makes it possible to detect the interactions of the numerous mechanisms and interrelationships.

In a second step the results of the simulations were compared to developments in the real world by applying concepts from graph theory which allowed the analysis of overall network dynamics. Although there were still some significant differences between the artificial evolution of network structures and the real world networks, the results looked promising, as they were able to reproduce at least qualitatively some developments which could also be observed in reality. The simulation facilitated the analysis of different scenarios, showing the influence of different environments as well as of policy measures aiming at the establishment of these new biotechnology-based industries.

In general, the model matched a number of the observed features of innovation in these sectors. Going through this analytical exercise has significantly sharpened our theoretical understanding of the key factors behind salient aspects of the development of networking in the biotechnology-based sectors and contributed to a more general understanding of innovation networks in other sectors.

The Knowledge-Intensive Business Services (KIBS) case study examined the construction and co-ordination of innovation networks supporting the development and diffusion of e-commerce and the particular role of knowledge-intensive services within these innovation networks. The empirical work in this study focused on one particular type of KIBS, the professional web-company and its interaction with its business clients. The development of an effective website is an essential prerequisite for companies wishing to engage in e-commerce. It is a misleading, but oft repeated, observation that basic web-pages are easy to design and that the syntax of HTML is relatively easy to learn. The construction of a website involves much more than the writing of a few web-pages. Rather, the professional web companies contacted by this report offer their clients bespoke packages that entail the putting together of a series hardware, software, programming and design elements in order to create a fully-functioning e-commerce website. In other words, web-companies are another type of integrator - a package integrator.

Another important role played by professional web companies is the education of clients, particularly those with little or no previous experience, about the potential and current limitations of e-commerce. Unfortunately the information asymmetry that exists between providers and clients means the latter are potential prey for ‘bad sellers’. These will undercut the competition in order to make short-term private gains while delivering sub-standard products to the end-user. By creating dissatisfied buyers that are unlikely to return to the market, these outfits are simultaneously “poisoning the well for others”. The establishment of good selling practice is therefore essential if Gresham’s Law - that bad ‘selling practice’ drives out the good - is to be avoided.

From the perspective of the internet, where customers and firms interact in e-commerce, a number of important issues arise when considering the role of political institutions within e-commerce. Particularly prominent were issues relating to the areas of access and social exclusion, data protection, trust relations, competition policy, standards-setting and IPR.

Large technical systems require a new sort of competition policy in which the spotlight is placed on inter-market relationships as well as intra-market conditions. As the DoJ - Microsoft court case has highlighted, monopolistic control of one area can confer significant leverage in another area, possibly stifling competition. Traditional perspectives on standards-setting also need to be revised. Innovation in network technologies is typically associated with several layers of standards that concern performance, design and interoperability. These cut across the traditional institutional demarcation of *de facto* market-driven standards and *de jure* standards set by government-sponsored bodies. The standards game is at the heart of the strategic battle being fought between the two rival networks of Microsoft and AOL-Sun-Oracle. Policy requires the development of a new, integrated perspective on standards-setting.

The case study on the role of inter-institutional networks in the diffusion of innovation in the combined heat and power technology (CHP) and the transformation of energy supply systems, was composed of three national studies of the developments in the UK, Germany and the Netherlands. It covered mainly the period from the early Eighties to the mid/late Nineties. This case study showed that setting up innovation networks alone is often not enough to establish an innovation. There is a high risk that the innovative effort will stop at an experimental stage and never reach wider application. In many cases, this is due to a lack of “embedding” of the innovations in a compatible structural context. It may require structural and contextual changes to enable the wider uptake of an otherwise promising innovation.

Regulatory and policy frameworks are critical elements of this context which can be influenced by policy. In fact, measures aiming to establish framework conditions conducive for innovations in a particular field, like energy supply, can be at least as efficient for creating innovations as the bottom-up operation of innovation networks. In the CHP case, structural and regulatory barriers were more constraining than technical and economic ones. The regulatory reforms in energy supply therefore opened up new opportunities for innovative energy supply solutions to emerge, though not necessarily to succeed. Most notably the British case also showed that a strategy that relies solely on transforming the framework does not necessarily lead to the kinds of innovative outputs desired from a policy perspective.

The most effective way of managing processes of diffusion of innovation in complex problem areas, (such as energy supply), seems to involve a combination of networking initiatives, that aim at stimulating self-organising forces and creating a variety of novel solutions, and adjustments of the framing regulatory and policy context to define a corridor of desired results.

The CHP cases also showed how important organisational innovations are in addition to the technological changes. The existence of potential carrier organisations that have an intrinsic interest in the kinds of innovation that is expected to emerge turned out to be decisive for establishing innovation networks. Their role is to enable and facilitate the dissemination of and learning process about good practices with an emerging technology and thus the establishment of an information network. They can be set up around established and respected key actors (e.g. industrial associations), but in view of their supporting function for the policy process it may be even better to set up an independent body.

The feasibility of both organisational changes and adjustments of the regulatory and policy context require networks that address these political aspects of innovation diffusion in large socio-technical systems to be in place. It is thus important to consider the wider political barriers to innovations as well and take them into account in the design of innovation policy.

3. The Theoretical Approach

As a theoretical approach the concept of self-organisation was adapted to the problem of innovation networks. In natural systems self-organisation describes the emergence and the dynamics of order. Its mechanism is circular causality, which

- demarcates the border between a system and its environment, i.e. marks off the region where the non-equilibrium is compensated from that part of the world where this cannot happen
- selects a specific form of compensation within the system, i.e. the compensation which reproduces its non-equilibrium
- stabilises a specific order against perturbations from the environment.

For the purpose of the SEIN project this concept of natural self-organisation was applied to innovation networks. For this reason the mechanism of circular causality was conceptualised for the realm of the social. As a general solution a circular relationship between the perception of (social) uncertainty and social activities for its reduction is assumed. Within this approach social order (formal and/or informal rules of social interactions) is a state of social dynamics where rules of interactions (structure) and the interactions (process) 'governed' by these rules reproduce each other because the rules are believed to guarantee a minimum of uncertainty within a specific social situation.

Because of turbulent markets and the complex dynamics of science and technology, the construction of innovations is subject to uncertainty: a lack of knowledge with respect to technical feasibility, economic success and social acceptance. The aim of an innovation network is to reduce this uncertainty through the co-operation of actors with different competences in order to produce this missing knowledge. Hypotheses about the function are established and checked by experiments like technical tests of components or prototypes. Hypotheses about the internal organisation of the network are checked by social experiments with different forms of co-operations. The circular relationship between these hypotheses and the experiences resulting from their conversion yields to an 'Eigenvalue' where hypothesis and experience reproduce each other as a solution of technological as well as social problems of innovations.

4. The Simulation Model

As mentioned before, the results of the case studies have been used to develop a description platform for a general model of innovation networks which has been used as an input for the simulation model. The model is a multi-agent system, that is, each of the actors is represented by an agent or 'object' in the program. The agents are designed to have the attributes of 'intelligent agents': autonomy, ability to interact with other agents; reactivity to signals from the environment; and pro-activity to engage in goal-directed behaviour. To model the knowledge that the actors possess, each is a given a kene, a structured collection of technological, political, social and economic capabilities. A kene is used to represent the knowledge base of an actor. Kenes change as actors acquire knowledge from other actors, and as they refine their knowledge through research and development. Kenes are made up of capabilities, and each actor has one or more abilities for each capability. For example, a biotechnology firm might have the capability to synthesise a particular pharmaceutical ingredient using a specific manufacturing operation (its ability). Actors use the knowledge represented in their kenes to produce artefacts, which, depending on the setting, might be a new design, a new drug, an invention for which a patent application could be made or a new discovery publishable in the scientific literature.

These artefacts are merely potential innovations. Only a small proportion of them become innovations, that is, successful new products and processes. The selection of which artefacts are innovations is modelled by the innovation oracle. The oracle rejects unsuccessful artefacts and rewards actors who produce successful innovations. For the purpose of the model, the oracle maintains a multi-dimensional 'innovation landscape' onto which all possible artefacts can be mapped. The 'height' of the landscape at the point where the proposed innovation is located is used to determine whether the artefact is an innovation, and if so, the amount of reward that flows back to the innovating actor. The form of the landscape is complex and unknown to the actors and they cannot anticipate with certainty how successful their innovations will prove to be. Successful innovations deform the landscape so that the reward for a second artefact identical to the first innovation is much reduced (this models the fact that in most fields the first mover will patent or copyright their innovation, with the result that subsequent identical artefacts from other producers receive little or no reward). As a result, the landscape co-evolves with the actors' kenes, and this is one way in which the model reproduces the complexity of the real world.

An actor's kene can develop as a result of three factors. First, an actor can use its resources to engage in 'incremental' or normal research and development (R&D). This improves the actor's ability relating to a specific capability, using its experience with previous artefacts. Second, the actor can elect to engage in 'radical' research in which entirely new artefacts are created from new combinations of the agent's capabilities. This corresponds to a firm deciding that it needs to branch out into a new area of expertise. Thirdly, an actor can learn from another actor with whom it is collaborating in a partnership. Partners share their knowledge when a partnership is formed, thereafter producing their own artefacts from their own kenes.

Actors are always available to join partnerships and whether they in fact do so depends on their strategy for developing their kenes, and also on whether they are able to find partners that are sufficiently attractive. All actors display an 'advertisement' consisting of a list of the capabilities that they possess (but not the details of the actual abilities that they have, since these will be confidential and in many cases, are not easily made explicit). For example, a biotechnology start-up might advertise that it is capable of performing some aspect of genomics, thus making itself attractive to other firms without that expertise, and possibly to venture capitalists or large firms seeking partners to develop new markets. Actors use the advertisements to judge whether the capabilities of a potential partner are sufficiently tempting to warrant forming a partnership. The costs of networking include sharing the rewards of innovation and the fact that partners have to give away their own knowledge as well as acquiring that of others.

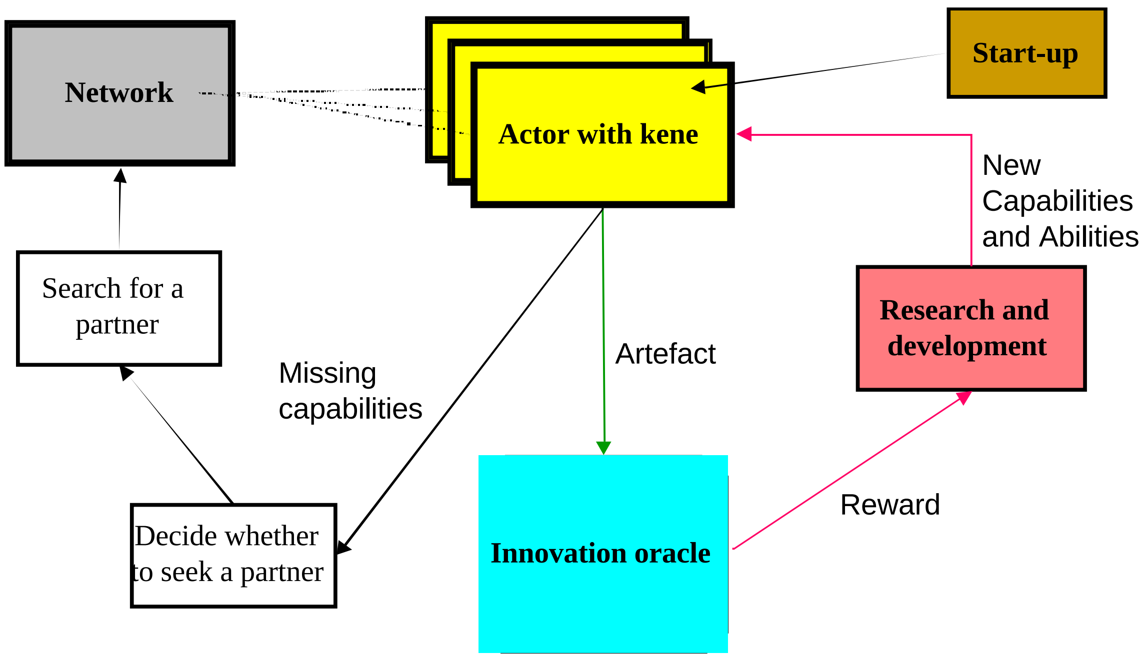
Partnerships are considered to be relatively short-term relationships focused on the development of particular products. They are typically binary relationships, although some actors may enter into a number of collaborations with different partners. In some fields, more permanent and more densely connected networks are also found. These networks always include a number of actors, bound into a collaboration which is more enduring than a partnership and which often has a distinct identity (ranging from an informal name to a legally based company, as with the Virtual centre of Excellence in mobile and Personal Communications, which is a non-profit limited company with its members as the shareholders). In the model, agents are able to convert a set of partnerships into a network provided that all the members have previously been partners. The advantage is that the network pools its members' capabilities and has a lower cost of collaboration than would have been the case if the members had only binary partner relationships.

The actors are driven by a need to maximise their rewards. Set against the rewards provided by the oracle for successful innovations are the costs of performing R&D and of collaboration and networking. Actors that fail to accumulate sufficient rewards to keep themselves in funds are declared bankrupt and 'die'. On the other hand, if the population of actors is successful in earning rewards, start-ups enter the field, copying the kenes of the most successful actors and thus increasing the level of competition.

To summarise: Actors as the basic elements of an innovation network are defined by their kenes, their competencies, and their structural and behavioural attributes which determine their ability to observe, anticipate and design the product space. Because these characteristics differ for each actor, innovation networks are heterogeneous. The main problem of an innovation network is to co-ordinate these heterogeneous actors. The co-ordination mechanism is the mechanism of self-organisation: Due to the increasing complexity of innovations so called 'go-it-alone' strategies are becoming more and more risky and co-operation with other actors is one way to reduce the uncertainty of the innovation problem. The emergence of innovation networks is driven by this uncertainty. The participation in an innovation network allows actors to have access to the capabilities of other actors which are not available by other means because of their tacit or local components. However, choosing a co-operative strategy also means sharing one's own knowledge with others. This is also a source of uncertainty because partners in an innovation network may become competitors in the market when the new product is developed. Balancing the risks and the advantages of co-operation is the main mechanism of social integration within an innovation network. This is a process of self-organisation because there is no external reference by means of which to find the appropriate way.

An innovation network produces an innovation. Depending on the context this might be a new design for a car, a new drug, new knowledge for which a patent is possible, or a new effect which could be used for a new technology. The production of these 'products' is again a self-organised process: the knowledge which is needed is not available, it must be produced and the production of knowledge can be characterised as a selection process applied on different hypotheses which have to be verified on the basis of its practical consequences. Within the SEIN simulation model this selection procedure is operationalised as an 'innovation oracle'. This is a kind of black box which evaluates and selects those 'proposals' that are to count as innovations. If the innovation oracle has passed the proposal, it has proved to be a successful innovation and a reward is paid to the successful innovators. If the innovation oracle refuses a proposal the innovation is not seen as being successful. Then the information oracle generates information about the type of knowledge that might be required to improve the current approach. The innovation oracle serves as a selecting environment for possible innovations.

The following figure shows the modelled structure of an innovation network:



In general, computer simulation helps to support, communicate and legitimise the policy decision process. In a way, applying IT techniques to the policy process is an autological operation which follows the rationale of technology policy itself, which is namely to strengthen the linkages between science and users. Here policy makers can apply funded technology to their own area. This feedback or even payback between science policy and IT simulation research forms the basic mechanism for a self-organising innovation network in the sense of the SEIN project.

5. The SEIN Approach to evaluation in science and technology policy

Because innovation networks integrate structural and dynamical perspectives, a radical change in evaluation theories, methods and tools is required. It is not only the product and its impact, which is the focus of evaluation, it is also the production within a network which requires new concepts of evaluation. Problems of network-performance, the integration of the context of application, the problem of social accountability pose new questions for evaluation. The SEIN perspective calls for a new evaluation approach for RTD programmes, which encourage innovation networks, such as the Framework Programmes of the European Commission. Taking those as a model, the approach refers to goal attainment questions arising within the European Framework Programmes and is mainly directed to EU policy-makers, though it can be used for national and regional RTD evaluation as well.

Within the SEIN General Simulation Model (GenSEIN, see section 4), there are a number of parameters in the model that can be adjusted to study various types of network environments. These include the form of the innovation landscape, the costs of networking and carrying out R&D, and the strategies that actors use to choose network partners. The basic set of parameters which can be varied, i.e. increased or reduced for special purposes, is given below:

Figure 1: The Parameters of GenSEIN

1. the number of abilities in each capability
2. the maximum level of expertise that anyone can have in any ability
3. the max. reward any innovation can ever obtain
4. form of landscape: one of (:random :peak :bumpy)
5. the number of actors at the start
6. the amount of capital every actor starts with
7. number of elements that make up a kene when it is created
8. the mean number of abilities required to produce an innovation
9. the deviation of the number of abilities required to produce an innovation
10. firm does radical R&D in cases where its capital is below this threshold
11. cost of one turn at radical R&D
12. cost of one turn at incremental R&D
13. cost per partner per turn of engaging in collaboration
14. cost per partner per turn of being in a network
15. how similar two actors have to be in order to link in a network
16. percentage chance that partner will be selected from friends, rather than popn. as a whole
17. number of actors needed to try to find one that is compatible for making a partnership
18. the score (reward) that must be obtained from the oracle for an innovation to be a success
19. the number of unsuccessful hypotheses in a row that causes actors to do radical research
20. number of unsuccessful innovations in a row after which a network is dissolved
21. the amount by which the fitness is reduced by a successful innovation
22. if the reward received by any actor during a step exceeds this, create a start-up

How can we use GenSEIN for evaluation purposes? Firstly we have to develop a catalogue of policy issues which can be transformed into questions the simulation model might be able to answer. Secondly, we have to show the connection between these questions and certain parameters or whole set-ups of the model. Thirdly, we have to present some examples for the kind of answers one could expect from such an exercise.

The first task is to operationalise the over-all question about the general impacts and consequences of policy strategies targeting innovation in networks which are supposed to be self-organising. This is a question about the emergence of two inter-related macro-phenomena, namely the formation of networks deriving from the collaboration decisions of single actors, and the successful production of innovations mostly deriving from knowledge exchanges within these networks. Policy cannot force either network formation or innovation production directly (section 1 of this chapter); however, it can target the conditions for the emergence of both macro phenomena because the micro level is accessible for policy intervention. This is crucial because on the macro level there is no central control mechanism and the performance there is completely dependent on the past history (cf. Holland 1992). The simulation shows how changes on the micro level (e.g. the number of agents involved) affect the emergence of macro phenomena (e.g. the probability of network formation); it also shows how elements (e.g. bits of knowledge) and systems (e.g. innovation as a system behaviour) connect to one another.

One possibility for categorising policy issues is therefore to collect open questions about the emergence of each macro phenomenon, network formation and innovation, and later look into their relations. Network formation, to begin with, involves the successful interaction of heterogeneous actors with different capabilities. However, networks, once established, are not stable but are permanently adapting to the changing requirements of their environment, which always shifts to different conditions, reacting to every innovation made by other actors or networks. For policy matters, it would be helpful to know whether there are construction directives for the setting up of innovation networks and whether there is something like an optimal network in terms of the sample of the actors involved, the modes of co-ordination and integration, the time table etc. Therefore, policy questions about network formation could address topics like:

- what are the effects of different micro conditions on the emergence of networks like;
- what are the effects of different actor strategies for partner search;
- what effects do actors' decisions about involvement in networks have;
- what situation on the actors' level generates collaborations and so networks;
- when do all actors join to form one network;
- what are supporting and what are preventing factors for networks;
- how do networks grow and/or die;
- what do the typical life cycles or "careers" of these networks look like;
- whether there are certain stages or phases they normally pass through;
- whether there are points where decline is likely to occur;
- what different types of networks are able to stabilise over time

The aim of the networks is to produce innovation. The model can show which type of networks, i.e. which combination of capabilities within a certain type of environment, is likely to reach this goal. If innovation is the macro phenomenon under investigation, any questions about what areas of knowledge, what sorts of capabilities, what strategies of learning etc. are supporting innovation in certain fields contribute to a list of relevant policy issues concerning research agendas. This list includes questions like:

- should all networks in any special field include complementary capabilities;

- how to encourage incremental innovation without harming radical innovation;
- what is the right blend between innovation and imitation for a certain area;
- what is the impact of decisions about R&D investment in this area;
- what is the effect of different types of learning on the exploration of the innovation space.

These questions now have to be translated into different parameter settings of the model. In addressing, for example, questions about the effects of different micro conditions on the emergence of networks, we can translate the specifying question about the effects of different actor strategies for partner search into a sensitivity analysis on the parameters 15 and 16. Changing the former will show what impact it has on the behaviour of the model when partners are mainly chosen from the group the choosing actor worked with before (the alternative is that the choosing actor picks his partners from the whole population). The latter parameter gives a choice between a "conservative" and a "revolutionary" partner search strategy: the first wants the future partner to be very similar to the choosing actor in terms of his capability set, the second wants him to be as different as possible. So far, experiments have indicated that, at the level of the population as a whole, the strategies that individual actors use to select partners are not very important, as they do not affect the general story of failure and success. If they use an unsuccessful strategy (and no innovations result from the network), the network and possibly the actors themselves die to be replaced by others, while the more successful networks continue and come to dominate the field.

This example shows how GenSEIN would allow to work through the whole list of policy issues mentioned above. However, this exercise would require a multitude of experiments which have not been carried out so far. The last part of this section illustrates the possible use of GenSEIN for scenario creation: it reports some experiments with supporting and constraining issues in order to create an "entrepreneurship scenario" (SEIN case study on KIBS). Two other scenarios have been created so far: adapted to the situation described by the VCE case study of SEIN, a "big-coalition scenario" was firstly reproduced and tested where one big network concerned with standard creation emerged. Secondly, the "industrial-innovation scenario" (SEIN case study on BioTech) showed the interaction between small high-tech companies and large diversified firms with considerable market knowledge. These two scenarios, however, are not described here. They can be found in Pyka, Gilbert and Ahrweiler (2001).

The Entrepreneurship Scenario (KIBS case study of SEIN)

The "entrepreneurship scenario" describes technological areas like IT where new small and medium companies enter and exit rapidly growing markets as competitors and collaborators in quick succession. The related cycles of innovation networks were observed in the KIBS case study of the SEIN Project (Knowledge Intensive Business Services in E-Commerce). This case study examined the construction and co-ordination of innovation networks supporting the development and diffusion of e-commerce, focussing on the role played by knowledge-intensive services in connection with their clients. The KIBS study provided a comparison between innovation networks in the Netherlands and the UK, showing the co-evolving dynamics of provider-user relationships in this area.

Important features of the KIBS case as an example for an entrepreneurship-scenario must be duly reproduced by the simulation. An extensive description of the KIBS case study can be found in Windrum and Birchenhall (2000); a summary of the main features of KIBS embedded in a SEIN case study comparison is available in Ahrweiler (1999). According to these recordings of empirical observations the main KIBS features consist of:

- the appearance of many small-sized networks
- the high number of market-entries (start-ups)
- the unequal capital distribution: a few rich actors (innovators and very successful imitators) and many actors with small capital
- actors who avoid doing radical research

In isolating those parameters responsible according to the KIBS case study material in order to describe and build a supportive environment for such technological areas, experiments with GenSEIN show that the "entrepreneurship scenario" is sensitive to the following parameters:

a) Changing the parameter "number of actors at start", we see that even a small number of initial actors[2] is capable of creating big markets containing many successful actors where numerous small ad-hoc collaborations take place in a highly competitive environment and many start-ups try to imitate successful firms, as indicated by the following growth curve. Starting with 30 actors, we can observe that even after a serious decrease in the actor population (around 30 per cent) invoked by innovation failure, the considerable success of a few actors can produce a "gold-digging atmosphere" which leads to massive market entries. Accordingly the entrepreneurship scenario reproduces a discontinuous appearance of new firms in swarms in the sense of Schumpeter (1912).

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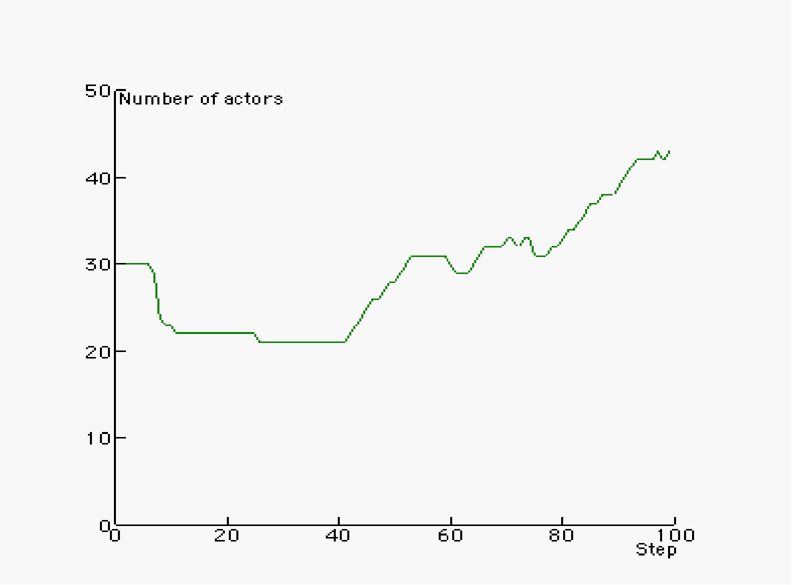
[2] The values for parameters are chosen in a way that allows relative statements referring to the four SEIN case studies. A "small number of initial actors" therefore means "a small number compared with input for simulations of the other SEIN case studies".

Figure 2: Results for Number of Actors



- Changing the parameter which is responsible for the time actors stick to their strategies adds to this effect (here, increase in the time of faithfulness to the strategy). Start-ups in the entrepreneurship scenario are imitators of a successful innovator but are not engaged in radical research themselves – a situation which is simulated through the high threshold value. Start-ups are quite resistant to failure and rather unwilling to switch to other technological options.
- While changing the parameter responsible for the degree of similarity between partners at the moment of choice we observe the appearance of many partnerships developing into small networks. A comparably low parameter value means that actors who cooperate may (but need not necessarily) be quite similar. This reproduces the situation in the KIBS case, although in KIBS networks different capabilities and areas of expertise have to be combined to achieve good market results (this mostly concerns differences between technological and economic capabilities). However, far more important is the fact that the difference between KIBS actors does not follow the border between different technological areas. The networks are rather homogenous and simple in their composition. Structurally, they are composed of similar units, namely small and medium sized enterprises (SMEs), all engaged in the E-commerce sector. Building on this general structural similarity, cooperating firms have a mutual value relationship: the activities of and returns to the R&D of an innovating firm crucially depend on the R&D activities of other surrounding firms. This situation leads to many ad-hoc co-operations in a highly competitive area.
- This competitive constellation is supported by changing the parameter which reduces gains when an innovation is only imitated. The situation that a successful innovation in an area dramatically reduces the profits further to be gained at that point indicates that it is crucial to be first and to be best and if not to at least be flexible enough to change innovative strategies and goals quickly. To accelerate the appearance of this effect even further, a new parameter was added to the initial set, namely the "depreciation costs": they indicate the fixed costs for

firms to do their business, i.e. motivate them even more to become active in the market as exit becomes more likely.

The example above illustrates how to reproduce computationally certain network scenarios guided by the findings of empirical case studies. The big advantage of computer simulation lies in the possibility of isolating single parameters. This enables the user of the simulation to gain access to a complex system which would otherwise be inaccessible for analytical methods. The access gained does not only cover the descriptive power of the model but also its implications for evaluating actions and decisions in the policy area.

According to the results of the simulation, what can R&D policy do to support entrepreneurship scenarios in different technology areas? On the one hand, it is necessary to create acceptable legal and economic conditions for SME's, especially for start-ups. On the other hand, it is crucial for young firms to be equipped with sufficient initial capital to enter the markets. Policy inputs would have to concern different regulative features:

- financial funding enabling technologically innovative start-ups to enter the respective markets;
- shaping an attractive environment (supportive tax rules, lean bureaucracy, management training etc.) for young firms to compensate for hazardous conditions in new technological areas.

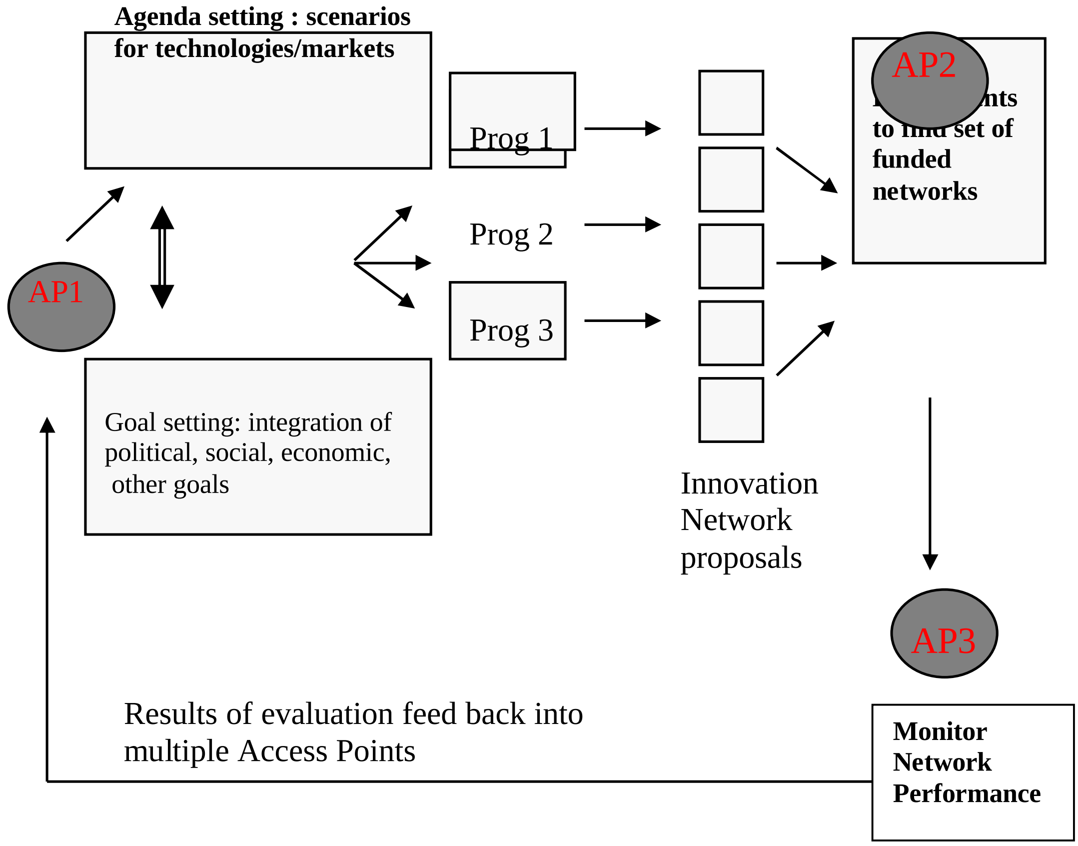
Furthermore, it was found that the entrepreneurship scenario is highly dependent on a few successful innovators who will take the lead with respect to the "big wave" of imitators following the first success. For policy-makers it would be a big advantage to be able to identify possible innovators who could start the process of building a new market. However, a direct triggering of innovation by finding and supporting the relevant innovators is never possible. Instead the point in time where an innovation actually takes place becomes crucial. Therefore, our experiments underline not only quite general and well-known possibilities for politicians to spur innovation, but also put emphasis on an important point, neglected more or less so far in the literature. In particular it is the window of opportunity which is opened up for a short period and which we additionally want to highlight. Then, the policy inputs mentioned above have overall importance. Outside this window in time all policy instruments designed to initiate and further these innovative dynamics are very likely not effective. Accordingly, it becomes crucially important for policy-makers

- to observe the R&D activities and to monitor the innovative space of a technological area;
- to develop their own expertise to identify successful innovators early in the process.

The Use of (Software) Instruments in the Policy Process

We now can point out some access points where computer simulations like GenSEIN can enter the policy process as helpful tools. In de Jong, Ahrweiler and Windrum (2001), the SEIN Evaluation Approach was theoretically considered, including a graphical representation of the policy process leading to the funding of innovation networks. This figure, based on the Evaluation and Learning System Approach (ELSA) developed by Technopolis (Guy et al., 1999), described the four levels of policy context, programme operation, project implementation and participants. It has been slightly changed here for our purposes:

Figure 9: Access points for computer simulation in the policy process



The figure shows three access points where computer simulations with GenSEIN could be used in the way we presented above. The first access point AP1 concerns the agenda setting process. Simulating "entrepreneurship scenarios", "big-coalition scenarios" or "industrial innovation scenarios" (Pyka, Gilbert and Ahrweiler 2001) for different technologies and markets helps to define hierarchies and priorities with regard to the funding of particular research areas. As illustrated in the "entrepreneurship scenario", simulation can for example show what will happen if in a new technological area many new market entries take place; additionally, it can immediately show what must be done to get these many entries. Moreover, GenSEIN shows how cooperation and networking influence innovation paths and market structures. Addressing questions like this, AP 1 supports the agenda setting process of policy making.

AP 2 introduces computer simulations like GenSEIN at a point where proposals for innovation networks must be evaluated to arrive at funding decisions. With GenSEIN it is possible to find out which set of actors is likely to produce sufficient innovation results in a particular area. We can test the composition of innovation networks: GenSEIN, for example, shows what different capability combinations and different numbers of capabilities in networks are likely to achieve what kind of innovation results.

AP3 is less a point than an area of access: here, the postulated permanent monitoring as an evaluation exercise of policy-makers can be supported by computer simulations like GenSEIN. The empirical outcome of the funded networks can be compared to the outputs of the simulation. In this process, it is possible to modify expectations, to trace causes why expectations were/were not fulfilled etc. Results from this exercise can be fed back into every part of the policy process.

The use of (software) instruments for policy decision making has been demonstrated, firstly by presenting a tool for basic network comparison on a more descriptive level, secondly by introducing a generic innovation network simulation model which is able to offer a platform for all sorts of policy-relevant experimentation. Work on these tools must be continued, including a "technology transfer" to the policy area where such instruments could be available to give daily assistance.

6. Policy Implications

One of the fundamental assumptions from which the SEIN project started was the recognition that innovation networks represent a new and increasingly important model by which knowledge and innovation are generated. While informal networking may already have been a relevant mechanism of knowledge transfer in the past, the formalisation of network relationships in research is a comparatively new phenomenon. The main policy interest of the SEIN project was to understand why so many research efforts fail to produce marketable innovations, and consequently what policy might contribute to improving this situation, taking into account the growing importance of this new network model of innovation. Furthermore, if innovation processes differ from previous times, what does this imply for policy, and for RTD policy in particular? In the following, we will try to highlight some "challenges" for RTD policy, brought up in the course of the conceptual and case-study work during the SEIN project. Whilst this interpretation of the findings is not necessarily shared by all SEIN partners, it nonetheless is a useful input in an ongoing debate.

Challenge 1: The integration of several knowledge domains

Although inter-disciplinarity as well as the enrolment of practitioners into research have been requested by innovation policy for many years, research work that crosses traditional borders remains difficult. There are serious difficulties involved in communicating across disciplines. This is first of all for a conceptual reason, namely the difficulty of establishing conceptual platforms or visions that could serve as orientation for researchers and other knowledge producers from diverse backgrounds. At the beginning of an innovation process several such visions compete with each other until a few of them establish themselves as leading paradigms. Moreover, codified as well as tacit pieces of knowledge need to be transferred, and the latter can only be transferred effectively by joint work.

The second reason is of a behavioural nature. It is very difficult to ensure the sustained cooperation of a broad range of actors in an innovation network. Incentives and expected benefits need to be associated with an innovation project to ensure support. The SEIN biotechnology case can be mentioned as a simple example where both large and small firms could perceive the benefits of cooperating in a network mode. The CHP cases show on the contrary how defection by one important actor can prevent or delay the emergence of an innovation network. Before we can give recommendations on the design of innovation networks, we need to understand the motivations for entering into network-type co-operations in a specific sector as well as possible.

RTD policy to interconnect the different knowledge domains needed for an innovation networking. The removal of barriers to mutual understanding, both codified and tacit, and a thorough consideration of potential interests and incentives for cooperation need to become key elements of a policy design to stimulate innovation networks.

Challenge 2: Skills and absorptive capacities needed to participate in INs

For actors and organisations to be able to participate effectively in innovation networks, they require particular skills and competencies which differ from traditional R&D skills. They need to be able to cope with the multiple rationalities brought into play by the broad range of actors and organisations involved in Mode 2 innovation networks (cognitive dimension).

Even if the individuals become more skilful and capable of understanding, communicating and cooperating with others, this does not assure the operation of Mode 2 innovation networks. The organisations they belong to are confronted with new requirements as well.

Finally, the coordination of different knowledge domains and contributions from a broad range of backgrounds, both in science and in application, requires an additional set of skills that are not easy to find in conventional science. For example, the experience from past EU research has shown that only a limited number of organisations is really able to operate as network nodes.

While individual skills development by means of education and training have been on the policy agendas in the RTD field for many years, the advancement of inter- and trans-disciplinary skills needed for Mode 2 is not yet well developed. At the level of organisations, the necessary skills seem to be even more underdeveloped.

In the SEIN project, the skills issue was probably most prominently addressed in the biotechnology case, where large firms were in need of particular search skills which they were not willing or able to develop in-house. In the CHP cases, many examples could be found of organisations that were simply not able to enter into network-type patterns of cooperation, whereas the VCE case showed very well that even organisations that are in principle competitors can get involved successfully in joint innovation networks.

A leap in communication, cooperation, coordination and inter-disciplinarity skills is required from individuals and even more so from organisations to be able to participate in Mode 2 innovation networks. These aspects need to find more prominent consideration in RTD programmes as compared to the conventional training and education policies along disciplinary lines.

Challenge 3: The balance between self-organisation and design

Among the factors that turned out to be decisive for improving the success of the innovation networks in the SEIN project was the balance between self-organising and exploratory processes to generate novel ideas on the one hand, and on the other the (political) requirement of goal orientation in order to get innovation results that contribute to societal or policy objectives. Maintaining this delicate balance could be seen as the essence of a policy approach that takes self-organisation seriously.

Innovation requires creativity, diversity and learning, which implies that the final outcomes of the innovation process cannot be predefined in detail right from the beginning. It should be left to the knowledge producers in the network to establish their research strategy, the partners they involve and how they organise themselves. However, it is evident that policy is less and less inclined to support activities that do not pursue a clearly defined social benefit (such as e.g. problem-oriented research). This implies that innovation needs to respond to certain objectives and to set up processes to ensure their achievement. The SEIN cases have underlined that one cannot design innovation networks in detail, but that their emergence can be stimulated by defining framework conditions, objectives, (financial) incentives and visions to guide their evolution, without calling into question their autonomy, diversity and self-organising character.

For example, in the VCE case rough objectives were set as well as the organising principles and basic compositions of the network, but the detailed implementation was left to the core partners. In the Dutch CHP case, policy intervention went even further because the core actor and carrier organisation of the envisaged innovation network was set up by government. Another element that turned out to be important for keeping an innovation network on track while admitting a high degree of self-organisation was the existence (or creation) of a guiding vision, as shown by most CHP cases as well as the VCE case.

Policy needs to strike a difficult balance between providing a creative and productive space for exploration that operates in a self-organising way and giving guidance with respect to the socially desirable outcome of innovation networks. This requires careful intervention using a variety of means: financial incentives, framework conditions, definition of objectives and visions.

Challenge 4: The balance between openness and closure

Innovation networks should be open for new information but stable with respect to their operations to enable a targeted production of knowledge and novel ideas. This balance between openness and stability is critical for producing a well-defined output. Networks that are very loose and open run the risk of not following a common objective. On the other hand, too tightly tied innovation networks become insulated from useful external inputs and run the risk of “lock in”. Mode 2 of knowledge production implies integrating the rationalities of application context (i.e. market and society) as well as of the policy context. While this is not a new finding, Mode 2 implies that the opening up towards other than scientific rationalities has to take place earlier than in the past, thus raising additional problems of maintaining the stability of innovation networks.

The need for openness thus needs to be balanced by additional mechanisms that help ensure the persistence of a network. For example, the involvement of lead organisations or core actors can give the network stability and leadership. The Dutch CHP case may be an extreme case in this respect because a lead organisation was created as a crystallisation point for the development and extension of the wider network of organisations in support of CHP. At the other end of the spectrum, the British case, was only very loosely organised. Another extreme case is the Internet, where essentially only the platform of exchange was provided.

Other elements that helped create a certain degree of stability in open networks are the building of trust and the existence (or not) of a self-perceived identity of the innovation network, i.e. whether the members were aware of its existence or not. While identity could not be observed in all SEIN cases, trust among network partners turned out to be a critical pre-condition for information exchange and co-operation.

> While innovation networks need to remain open to new sources of ideas from outside, they also need stability to remain on a targeted trajectory. The existence of a lead organisation, but also a clear mission and identity can help keep them on track, with a high degree of trust being a critical pre-condition for co-operation.

Challenge 5: From innovation to diffusion networks

Mode 2 emphasises the importance of learning and knowledge production being driven by the application context. This implies that actors who in earlier models of innovation only started to matter in the diffusion phase now enter the scene much earlier. While it is well known that innovation and diffusion are inter-related processes which fertilise each other, in a Mode 2 context this interdependence is actually reinforced.

Obviously, this is of particular importance in sectors where innovation takes place very much as a result of new requirements in the application context (e.g. structural change, regulations), such as e.g. in the CHP case study of SEIN. Science-driven sectors may put a more targeted effort into network development for R&D. This has clear implications for the design of policy programmes and the innovation phases they ought to address. The focus on diffusion also re-emphasises the need to have a more differentiated look at the requirements for innovation networks in their application context (often sectorial). In other words, Mode 2 of knowledge production matters to different degrees in different sectors.

If, as we have just argued, diffusion should be considered more prominently in the design of innovation networks, then the question of technological succession and replacement becomes more prominent in the analysis of innovation networks. It redirects attention to the issue of what comes after an innovation network, whether networks are a good model for describing all the phases of innovation processes or not and how innovation networks would have to change once they move closer to the market phase. In fact, many innovation networks disappear soon after market introduction. Unless we are dealing with a completely new field of inquiry (e.g. bio-informatics), we even have to take into account what was already in place in the field that the innovation network addresses. For policy, the blurring of the boundaries between innovation and diffusion implies that it is becoming increasingly difficult to distinguish between pre-competitive and competitive research.

> Mode 2 reinforces the argument that the diffusion phase should be addressed more carefully in innovation policy. The growing involvement of non-science actors in knowledge production makes the distinction between pre-competitive and competitive research more and more obsolete. However, it is not yet clear whether the network model is a good description for all phases of the innovation process, or only for some of them.

Challenge 6: Uncertain outcomes and the need for new forms of evaluation practices

Related to the diffusion issue is the growing difficulty to anticipate the final outcome of knowledge production in Mode 2. As in conventional Mode 1 research, it can differ from what was originally thought of, but in Mode 2 this uncertainty is augmented by the inclusion of considerations from the application phase. This openness in terms of content needs to be counter-balanced by the adjusting function of continuous evaluation procedures (de Jong/Ahrweiler/Windrum 2000).

This implies that evaluation procedures should be seen as a learning process for those actively involved in an innovation network, not as a comparison of what was originally planned with the final result. In line with the network model of innovation, the evaluation process should also involve a broader range of actors and stakeholders, including in particular also those who are part of the innovation network. In fact, evaluation under Mode 2 conditions should be understood as a self-assessment process of the roles and contributions of the research and non-research actors involved in an innovation network.

Evaluation practices need to change in order to take account of the open mode of operation of innovation networks and of the need to leave its final outputs loosely defined, while monitoring its advancement. In other words, evaluation needs to change from an output control to a support process for those conducting the research work.

Challenge 7: Timing and coordination of policies affecting innovation networks

Another crucial issue for policy is the timing of support measures for innovation networks. It has been argued before that learning in a network mode comprises both the diffusion and the innovation phase, i.e. they can no longer be clearly distinguished. As a consequence, it is necessary to consider the impacts of RTD policy simultaneously with the adjustments of the regulatory framework of the application context. It also concerns the issue of phasing out support measures of RTD policy at the right moment in time, i.e. in particular when the framework conditions have been adjusted in such a way as to accommodate the innovations in question.

In the SEIN cases this conflict between RTD policy and the conditions of the application context could be observed with some clarity in the CHP example. In fact, it took years until the regulatory frameworks were adjusted to accommodate the adoption of CHP. On the other hand, regulatory changes (e.g. environmental, but also liberalisation) gave important impulses for innovation activities. Innovation networks should thus be constructed in a way which allows them to anticipate the conditions of the application context, including its specific regulatory, legal, organisational and demand aspects. If, however, contradictory signals are given by RTD policy on the one hand (e.g. in terms of research objectives) and framing policies in the application context on the other, no clear orientation can be given for the work of an innovation network. So, in biotechnology, the enthusiasm for new scientific advances in this field have often been counterbalanced by the critical stance of the public and consumer policy with respect to new types of food or drugs, and of their production.

The success of innovation networks depends on their ability to anticipate or prepare for the conditions of the application context. As they depend on many different policy fields a better coordination of RTD policy with other domains is becoming more important, both in terms of substance and timing of measures.

Challenge 8: New governance mechanisms for a Mode 2 RTD policy?

So far, a number of new requirements have been formulated for RTD policy. The policy realm alone cannot meet these requirements in a legitimate and effective way. Consequently, new forms of governance, if you like Mode 2 governance in a Mode 2 society, will be needed. It would be based on the involvement of a broader range of actors and stakeholders than in the past, thus departing from an experts-only political culture.

Such a culture would be based on the recognition that policy and policy networks are inherent parts of the innovation process. Mode 2 RTD policies should then be based more on a concerted action type of initiative, involving not only the usual interest groups but a wider range of relevant knowledge producers. In other words, networks of innovative users and suppliers are not enough, but need to be complemented by networks that address the policy context. Policy networks become an integral part of the knowledge production process, implying that the clear-cut borderline between policy and science becomes increasingly blurred.

As a consequence of Mode 2 innovation networks the governance mechanisms of RTD policy need to be adjusted as well. A broader range of actors and stakeholders should be involved in policy design. Policy itself needs to be understood as a learning process in networks that is closely related to the operation of innovation networks.

Further steps towards a new RTD policy strategy?

The results of SEIN indicate that indeed the network model may be appropriate for describing innovation processes in many different fields. The challenges discussed above give indications why past innovation network policies have failed and highlight aspects to which the attention of RTD policy should be directed in the future. It has been attempted to give some constructive hints what could actually be done to improve RTD policies for innovation networks, but this could not be more than a first attempt to extract policy-relevant information from the SEIN project and other, related research work.

Such a discussion is timely because right now the processes and mechanisms for the European Research Area (ERA) are being defined, and the issue of networked research is high on the agendas. However, one should be cautious in adopting a single model. Even when merely comparing the four SEIN cases it became obvious how different innovation networks can be in terms of their structure, organisation, involvement, etc. A differentiated approach should thus be pursued with respect to innovation networks in European RTD. Centres of scientific excellence will require a different model than networks of applied industrial research (e.g. demonstration projects) or networks of knowledge production with a high degree of public involvement (e.g. local agenda 21 actions).

The discussion on the European Research Area also points to an important issue that seems to have been forgotten in the debates about networks, namely the spatial dimension of networks and the location of their members. Information and telecommunication technologies have certainly facilitated information exchange in networks, but face-to-face interaction and spatial proximity are still important factors facilitating innovation. On the other hand, the ERA concept and European research in general relies on trans-national cooperation in research. In view of the new order of magnitude of networking envisaged for the future, the limitations of spatial distance in innovation networks should be reconsidered carefully.

In terms of research themes, many national research programmes over the last years as well as the 5th Framework Programme have adopted a problem-oriented approach to defining thematic priorities. This was pretty much in line with a Mode 2 understanding of knowledge production. As regards the current plans for a new Framework Programme, the issue of problem orientation vs. S&T orientation is less clear as yet, and it may affect the relevance of Mode 2 for designing network-oriented RTD policies.

Finally, it is important to note that the targeted promotion of innovation networks entails the risk of reducing the variety of research efforts. While it is certainly justified to concentrate public money on the most promising activities with respect to the public benefit, there is still a risk of failure, even if the aforementioned challenges are thoroughly addressed. Innovation networks may still fail to produce the expected outcome, in spite of continuous evaluation efforts and the in-built flexibility and learning mechanisms. In view of the large-scale of the network-based research initiatives foreseen in the new Framework Programme, this is a high-risk strategy. European policy should be aware of that risk, and of the benefits of a well distributed and robust portfolio of research actions of a limited size as compared to a small number of highly concentrated and large-scale efforts.

7. Dissemination and Exploitation of Results

The goal of this task was threefold. First of all its aim is to guarantee the communication between the project partners. Secondly the goal was to inform a broad range of people on the project's progress and results. And finally the aim was to establish contact with and foster an active involvement of possible users in the project to check for the practical reliability of the project and meet the needs of practitioners.

To guarantee a well-functioning communication between the partners being distributed over five countries, a mailing list was installed at sein@soc.surrey.ac.uk, including all project members.

To inform a broad range of people the following activities were being carried out:

- Website: Set-up and constant up-date
- Project Papers: 16 project papers resulted from the project
- Newsletters: Three newsletters briefly informed on the project's progress and results.
- Literature list: A literature list on innovation research and innovation networks was set up in German.

Website:

A project-web-site was set up to provide the network of practitioners of evaluation with adequate information about the project. This site was installed at http://www.uni-bielefeld.de/iwt/sein and has constantly been up-dated with new information. This included the announcement of workshops and presentation of their results, project papers, newsletters, the theoretical approach/background of the project.

Newsletters:

Three Newsletters have been published during the project period.

a) August 1999

The first newsletters basically presented the final research designs of the four case-studies and two interpretative perspectives that had been developed up to that stage of the project: the typology approach of innovation networks and the concept of self-organisation with respect to two of the case-studies.

As the case studies covered a broad variety of different characteristics, a general theoretical framework applying to all sorts of innovation networks, a phenomenological device, was chosen: a typology of innovation networks was started which had to be further developed due to empirical findings in the case studies and to logical possibilities in the modelling area. The SEIN typology diagram shows a categorial pattern of nested characteristics applying to innovation networks. The concrete networks were then described using this heuristic.

b) March 2000

The final project reports of the case studies are part of this second newsletter. Furthermore the Simulation Approach of the SEIN project is presented, this being a Platform Model of Innovation Networks. The role of simulation in a platform is not to create a facsimile of any particular innovation network that could be used for prediction, but to use simulation to assist in the exploration of the consequences of various assumptions and initial conditions following the different case studies as well as a 'generic' theoretical case, that is, to use simulation as a tool for the design and refinement of theory. Finally the status of the SEIN evaluation approach for R&D programmes is presented. To develop an appropriate methodology, WP7 uses a combination of the case study and simulation modelling as a means of conducting meta-evaluations. The range of methods includes, amongst others, essay reviews of evaluation reports, and empirical re-evaluation using the same or new data sets.

c) December 2000

This third and final newsletter presented crucial issues on the main policy interest, which were the reasons for the failure of many research efforts in producing marketable innovations and possible contributions of policy to improve this situation. Furthermore results from the simulation that was used to model the growth of Innovation Networks (IN) are described. It also presents the SEIN evaluation approach, which came up with a framework for policy-makers, including some new methodological tools to deal with uncertainties in the area of planning, foresight and prediction. Finally the SEIN evaluation approach is presented in its development

Project-papers:

A number of project papers resulted from the project.

No. 1
Innovation Networks in Economics. From the incentive-based to the knowledge-based approaches, by Andreas Pyka (INRA-SERD), April 1999

No. 2
Self-Organisation: The Emergence of Order. From local interactions to global structures, by Günter Küppers (IWT), July 1999

No. 3
Towards a general description of innovation networks. Commonalities and differences in the SEIN case studies, by Petra Ahrweiler (IWT), September 1999

No. 4
Political forces shaping the innovation and diffusion of technologies: an overview, by Matthias Weber (IPTS) & Sabine Paul (IWT), September 1999

No. 5
Conceptual Framework for a Simulation Model of Biotechnology Innovation Networks, by Paolo Saviotti (INRA-SERD) & Andreas Pyka (INRA-SERD), October 1999

No. 6
The Self-Organisation of Innovation Networks: An Economist's View, by Andreas Pyka (INRA) & Paul Windrum (MERIT), October 1999

No. 7
Innovation Networks in the Biotechnology-Based Sectors by Andreas Pyka (INRA-SERD)& Paolo Saviotti (INRA-SERD), February 2000

No. 8

The Development of a Generic Innovation Network Simulation Platform, by Nigel Gilbert (University of Surrey), Andreas Pyka (INRA-SERD) & Glenn E.P. Ropella (Swarm Corporation), May 2000

No. 9
Foundations of Evaluation Theory: A review, by Simone de Jong & Paul Windrum (MERIT/Infonomics), April 2000

No. 10
Back from the brink: Microsoft and the strategic use of standards in the Browser Wars, by Paul Windrum

No. 11
Internet Access in the Netherlands: Themes and Issues, by Paul Windrum and Simone de Jong (MERIT), July 2000

No. 12
Modelling technological successions in E-Commerce, by Paul Windrum (MERIT) and Chris Birchenhall (University of Manchester), July 2000

No. 13
Evaluation and Knowledge Production, by Simone de Jong, Petra Ahrweiler and Paul Windrum (IWT/MERIT), October 2000

No. 14
The role of networks for innovation diffusion and system change. CHP in UK, Germany and the Netherlands, by K. Matthias Weber (IPTS), December 2000

No. 15
Theoretical Considerations of the SEIN Evaluation Approach. S.E.A. I, by Simone de Jong, Petra Ahrweiler and Paul Windrum (MERIT/IWT), March 2001

To guarantee a distribution of these project papers they were published on the project's website (www.uni-bielefeld.de/iwt/sein/papers.htm) and distributed to the list of people from the European Community, science and industry abroad.

Literature list:

A literature list on innovation research and innovation networks was set up at the Institute for Science and Technology Studies. It covers a broad range of topics in this research field, such as evolutionary economy, sociology of industry, innovation research, institutionalism, network research etc. This is however only available in German.

Workshops:

The development of a simulation model of innovation networks: for a better understanding of its structure and dynamics and its use as a new tool for evaluation processes the integration of possible users is required as soon as possible. In addition, both the simulation model and the evaluation tool need to be recognised as useful within a broad variety of applicants: politicians (innovation policy), managers (innovation practice), researchers (innovation management) and last but not least scientists (innovation theories). Consequently, a number of workshops was organised during the project with participants from Commission Services, national governments and relevant research communities.

London January 2000

Theme: Innovation Networks: Theory and Policy

The purpose of this workshop was to discuss preliminary results and policy implications of the case studies' results with policy practitioners from the European Union & national institutions, and practitioners from the technological fields under investigation. Presentations were given on the four case studies. These presentations were put on the project's website and opened up for discussion. This was done by providing forms for comments which could be sent to the project management.

'Innovation Networks: Theory and Policy', January 14th 2000
The European Commission Representation in the UK
8 Storey's Gate, London SW1P 3AT

9.30 - 10.00 Coffee
10.00 - 10.15 Welcome (Günter Küppers) and Introduction (Nigel Gilbert)

10.15 – 12.15 Session 1
Chair: Paul Windrum
Innovation Networks by Design: The case of the Mobile VCE (Janet Vaux)
Discussant: Dr. Ian Groves / Cellnet
Targeted construction or unintended emergence of networks? Innovation diffusion of CHP technology in different European countries (Matthias Weber)
Discussant: Dr. Stewart Russell / University of Wollongong

12.15 – 1.45 Lunch

1.45 – 3. 45 Session 2
Chair: Paolo Saviotti
Knowledge Pools and Innovation Networks: The Role of Knowledge-Intensive Services (Paul Windrum)
Discussant: Nigel Stewart / XTML
Innovation Networks in Biotechnology - Mechanisms of Network Formation
(Andreas Pyka)
Discussant: Prof. Dr. Gunnar Eliasson / Royal Institute of Technology

3.45 – 4.15 Tea

4.15 – 5.00 Session 3
Round Table: Innovation Policy

Chair:	Günter Küppers
Discussants:	Adrian Alsop/Deputy Director of Research ESRC, UK
	David Clark/Director of Programmes EPSRC, UK
	Andrew Sors/DG XII European Commission
	Patrick McDonald/Department of Trade & Industry, UK
	Prof. Jean Bourlès/DG XII European Commission
	Dr. Kieron Flanagan/PREST

Brussels

The purpose of the second workshop was to discuss the simulation models which were developed in the case studies with practitioners from industry, the EU and a management consultant as well as with other scientists working on simulation. Therefore presentations were given on the three simulation models before a panel was held with practitioners (see agenda).

Programme
26th June
EU, rue Montoyer 75, 1040 Brussels, Room R3
Time: 10.00 - 17.00

9.30 - 10.00 Coffee
10.00 – 10.15 Welcome and Introduction (Günter Küppers)
10.15 – 11.00
Comparative framework of the case-studies (Petra Ahrweiler)
11.00 – 11.45
The role of computer simulation within policy making (Peter Allen)
11.45 – 12.30
The general simulation model (Nigel Gilbert, Andreas Pyka, Petra Ahrweiler)

12.30 – 14.00 Lunch

14.00 – 14.45
The SEIN-evaluation approach (Paul Windrum)
14. 45 - 15. 45 General Discussions I
15.45 – 16.15 Coffee
16.15 – 17.00 General Discussions II
Discussants
Peter Allen (University of Cranfield), Gerhard Braeunling (EU, ADAPT initiative)* , Günter Clar (EU, DG Research, Policy Coordination and Strategy Unit), Georgio Clariotti (EU, DG Research, SME and Innovation Unit), Gilbert Fayl (EU, DG Research/Evaluation Unit), Marshall Hsia (EU, DG Research)*, Dr. Nancy A. Neff (United Technologies Corporation Research Center), Mike Rogers (EU, DG Information Society)

University of Augsburg October 2000:

Theme: Applied Simulation Analysis

This workshop included presentations of the SEIN Simulation Approach as well as sessions on simulation in sociology and economy.

Thursday 19th October around 8:00 pm arrival and dinner
Friday 20th October

9:00 – 9:15 am Coffee and Welcome Address by Günther Küppers (University of Bielefeld)

9:15 – 10:00 am The SEIN – simulation approach by Nigel Gilbert (University of Surrey) and Andreas Pyka (INRA/SERD Grenoble)

10:00 - 10.30 am Coffee break

10:30 – 11:30 am Session A: Simulations in Sociology; Chair: Petra Ahrweiler
• Lake Anderson Revisited by Agents by Klaus Troitzsch (University of Koblenz/Landau)
• Competition as a Test of Hypotheses: Simulation of Knowledge-generating Processes in Markets by Nicole Saam (Ludwig-Maximilians University of Munich) and Wolfgang Kerber (Phillips University of Marburg)

11:30 – 1:00 pm Lunch break

1:00 – 2:00 pm Session B: Simulations in Economics I; Chair: Paul Windrum
• History Friendly Models by Luigi Orsenigo (Bocconi University Milan) and Franco Malerba (Bocconi University Milan)*

• Technological Spillovers and the Spatial Distribution of Industries by Thomas Brenner (MPIEW Jena)

2:00 – 3:00 pm Coffee break

3:00 – 4:00 pm Session C: Simulations in Economics II; Chair: Paolo Saviotti
• Modelling of Knowledge, Capital Formation and Innovation Behaviour within Micro-based Profit-oriented and Correlated Decision Processes by Günter Haag and Philipp Liedl (Steinbeis Transferzentrum Angewandte Systemanalyse, Stuttgart)
• Functional Search in Complex Evolutionary Environments – Examining an Empirical Tool by Uwe Cantner (Friedrich Schiller University Jena), Bernd Ebersberger and Horst Hanusch (University of Augsburg)

4:00 – 4:30 Closing Session

University of Maastricht, November 10th 2000

Theme: Changing Production of Knowledge - Consequences for Evaluation

As this workshop focussed on the consequences of Mode 2 knowledge production for the evaluation of Innovation Networks, sessions on Mode 2 knowledge production were held l on evaluation approaches as well.

Friday November 10 10:00 – 10:15 Coffee and Welcome Address by Günter Küppers (SEIN project co-ordinator, University of Bielefeld) 10:15 – 10:30 Introduction to Session A by Paul Windrum (SEIN, MERIT) 10:30 – 12:30 Session A: Mode 2 Knowledge Production: Theory or Policy? Chair: Paul Windrum • The Post-Modern Research System by Barend van der Meulen (University of Twente) • Mode 2: Descriptive Inventory or Self-fulfilling Prophecy? by Michael Guggenheim and Christian Pohl (Swiss Federal Institute of Technology (ETH)) • The Changing Role of Public Sector Research in the European Policy Landscape by Philippe Laredo (Centre de Sociologie d'Innovation, École des Mines) 12:30 – 13:45 Lunch break 13:45 – 14:00 Introduction to Session B by Petra Ahrweiler (SEIN, University of Bielefeld) 14:00 – 16.00 Session B: Evaluation of Innovation Networks Chair: Petra Ahrweiler • Options for Evaluation by Ken Guy (Wiseguys) • Evaluation and Foresight by Michael Keenan (PREST) • Evaluation and Policy Making by Gilbert Fayl (Research DG, European Commission) 16.00 – 17.00 Final Debate and Closure

Final Conference, April 19th-20th 2001

At the final conference organised in collaboration with IDEFI, the attempt was to discuss the project results with a broader community of economists.

Programme

Thursday, April 19
09:00-12:00 (10:30-10:45 Coffee)
1. Innovation Networks: New Ways of Knowledge Production
Chair: Günter Küppers
SEIN Presentation: Günter Küppers: Complexity, Self-Organisation, and Innovation Networks
Hartmut Hirsch-Kreinsen: Innovation Networks: Coordination Problems and Developmental Perspectives
Alexander Eichelpasch: The InnoRegio Contest as a New Way to Promote Regional Innovative Networks - First Empirical Results
Peter Allen: Modelling Evolving Networks and Distributed Learning
12:00-14:00 Lunch
14:00-16:00
2. SEIN Meets Practice, Workshop on SEIN Simulation Model and Evaluation Tool
Chair: Nigel Gilbert
SEIN Presentation: Nigel Gilbert, Andreas Pyka, Petra Ahrweiler: The SEIN Simulation Model of Innovation Networks
Discussion
16:00-16:30 Coffee
16:30-18:00
3. New Methodologies in the Evaluation of Innovation Networks
Chair: Mathias Weber
SEIN Presentation: Petra Ahrweiler: Theoretical Considerations of the SEIN Evaluation Approach
19:30 Dinner
Friday April 20

9:00-12:00 (10:30-10:45 Coffee)
4. Innovation Networks: New Challenges for RTD Policy?

Chair: Paolo Saviotti
SEIN Presentation: Matthias Weber: Policy implication of the SEIN approach
Bernhard Truffer: The Social Construction of the Swiss Green Electricity Standard - Innovation Networks in a Politically Sensitive Product Sector
12:00-14:00 Lunch

End of conference

Finally it has to be mentioned that both the simulation model and the evaluation tool are only to be taken as preliminary versions. Following the end of the project both will be developed further to make them useful for practical purposes. The evaluation tool will be developed in such a way as to be usable for complex innovation processes.

Partners and contact persons

The following staff has been appointed during the project.

Surrey: Janet Vaux, E-Mail: j.vaux@soc.surrey.ac.uk;

Sevilla: Stéphane Isoard, E-Mail: stephane.isoard@jrc.es;

Grenoble: Andreas Pyka, E-Mail: pyka@grenoble.inra.fr

Sylvie Micheland

Merit: Chris Birchenhall, E-Mail: chris.birchenhall@man.ac.uk hired as third party assistance. Monika Suri provided administrative assistance to MERIT on a short-term basis; Wilma Coenegrachts, E-maiL: Wilma.Coenegrachts@MERIT.UNIMAAS.NL.

Bielefeld: Petra Ahrweiler, E-Mail: petra.ahrweiler@joice.net or petra.ahrweiler@post-uni-bielefeld.de; Sabine Paul, E-Mail: spaul@iwt.uni-bielefeld.de; Matthias Groß, E-Mail: mgrosz@uni-bielefeld.de; Uli Kowol, E-Mail: uli.kowol@uni-bielefeld.de; Zhijia Zhou, E-Mail: zjzhou@uni-bielefeld.de; Anke Jobmann, E-Mail: jobmann@iwt.uni-bielefeld.de; Glen Ropella, Swarm Corporation E-Mail: gepr@swarm.com, hired as third party assistance.

8. References

Ahrweiler, P., (1999), Towards a General description of innovation networks: commonalities and differences in the SEIN case studies SEIN working paper 3

Bell, Daniel (1973), the coming of post-industrial society: a venture in social forecasting. New York, Basic books

De Jong, S., Paul Windrum, P., (2000). "Evaluation Theory: A Review." SEIN project paper 9.

De Jong, S., P. Ahrweiler and P. Windrum (2001): Theoretical Considerations of the SEIN Evaluation Approach S.E.A. I, SEIN Working Paper.

Freeman, C., 1991: Network of Innovators: A sysnthesis of research issues, in: Research Policy, Vol. 20, 499-514.

Gibbons, M., Limoges, C., Nowotney, H., Schwartzman, S., Scott, P., Trow M., (1994) The new Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies. London, Sage Publications.

Guy, Ken, John Clark, Katalin Balazs, James Stroyan and Erik Arnold (1998). Strategic Options for the Evaluation of the R&D Programmes of the European Union. November 1998, prepared for STOA.: http://www.technopolis.co.uk/reports/stoa

Machlup, F. (1984), The Öconomic Information and Human Capital, Prinston University Press, Prinston = "Öconomic" and "Prinston"

Malerba, F. (1992) 'Learning by Firms and Incremental Technical Change', The Economic Journal, 102, 845-849.

Pyka, A. and P. Saviotti, (2000), 'Innovation Networks in the Biotechnology-Based Sectors', SEIN-Project Paper No. 7, Online: http://www.uni-bielefeld.de/iwt/sein/papers.html

Pyka, A., Gilbert, N., Ahrweiler, P., (2001), Simulating Innovation Networks. SEIN Working Paper.

Rycroft, R. W. and D. E. Kash (1999), The Complexity Challenge. Technological Innovation for the 21st Century, Pinter, London, New York.

Schumpeter, J.A. (1912), Theorie der wirtschaftlichen Entwicklung, Duncker & Humblot, Berlin.

Stehr, N., (1994), Arbeit, Eigentum und Wissen, Zur Theorie von Wissensgesellschaften, Frankfurt: Suhrkamp.

Windrum, P. , Birchenhall, C. (2000), Modelling technological succession in E-commerce. SEIN project paper 11.

Zuscovitch, E. and M. Justmann (1995), 'Networks, sustainable differentiation, and economic development', in D. Batten, J. Casti, and R. Thord (eds.), Networks in Action, Economics and Human Knowledge, Berlin: Springer Verlag.

9. Annexes

Petra Ahrweiler
Publications

- P. Ahrweiler, N. Gilbert, A. Pyka: "Simulating Innovation Networks", in: Research Policy, Special Issue, to be published

Conferences/Seminars

- Deutscher Soziologentag, Cologne, D., September 2000,
- 4S/EASST, Vienna, A., September 2000,
- ISARC33, Cologne, D., Oktober 2000,
- GWTF Annual Meeting, Erlangen-Nürnberg, D., November 2000,
- Cognitive Science Workshop, Freiburg, D., February 2001,
- IK 2001, Günne/Möhnesee, D., March 2001

Nigel Gilbert
Publications

- N. Gilbert, P. Ahrweiler, A. Pyka: "Understanding Innovation networks through Simulation" in: Arnold Heemink, Len Dekker, Henk de Swaan Arons, Iva Smit and Theo van Stijn, Shaping Future with Simulation, Proceedings of the 4th EUROSIM Conference, Delft, the Netherlands, June 2001

- N. Gilbert, A. Pyka, P. Ahrweiler: "Innovation Networks - A Simulation Approach", in: Journal of Artificial Societies and Social Simulation vol. 4, no. 3, 2000 http://www.soc.surrey.ac.uk/JASSS/4/3/8.html

Conferences/Seminars

- N. Gilbert, J. Vaux : Innovation networks: "The Mobile VCE case study", at International Conference on Complex Systems, New England Complex Systems Institute in Nashua, New Hampshire, May 2000

- N. Gilbert, P. Ahrweiler, A. Pyka : "Simulating Self-Organizing Innovation Networks", at International Conference on Complex Systems, the New England Complex Systems Institute in Nashua, New Hampshire, May 2000

- N. Gilbert : "Innovation networks: a policy model" at RAND Workshop on Complexity and Public Policy Complex Systems and Policy Analysis: New Tools for a New Millennium, Washington, DC, September 2000 http://www.rand.org/scitech/stpi/Events/Complexity/gilbert.pdf

Günter Küppers
Publications

- U. Kowol, G. Küppers: "Innovation Networks: A New Approach to Innovation Dynamics", in: Marina van Geenhuizen, David V. Gibson and Manuel V. Heitor (Eds.) Innovation and

Regional Development in the Network Society, Technology Policy and Innovation, Volume 7, to be published

Conferences/Seminars

- "The Order of the Social: Interaction in Networks", Seminar University of Bielefeld, 2000
- "Innovationsnetzwerke", Seminar "Graduierten Kolleg Genese, Strukturen und Folgen von Wissenschaft und Technik", Universität Bielefeld, 2001
- "New Paradigms in RTD Policy, The Dynamics of Policy Networks" at EASST/4S Wien, 2000
- "Innovation Networks: A New Approach to Innovation Dynamics", at 5th International Conference on Technology Policy and Innovation, The Hague, Netherlands, 27-29 June 2001

Andreas Pyka
Publications

- A. Pyka: (Ed): "Applied Simulation Analyis", in: Special Issue of the Journal of Artifical Social Simulation Studies (JASSS), June 2001
- A. Pyka: "Innovation Networks in Economics – From the incentive-based to the knowledge-based Approaches", in: European Journal of Innovation Management, forthcoming
- A. Pyka: "The Self-Organisation of Innovation Networks", with Paul Windrum Economics of Innovation and New Technology, forthcoming

Conferences/Seminars

- "Twin Peaks - What the Knowledge Based Approach of Evolutionary Economics can say about the World Income Distribution", at European Meeting on Applied Evolutionary Economics (EMAEE), Université Pierre Mendes France, from 7th to. 9th June in Grenoble, 2000
- Jahrestagung des Ausschusses 'Evolutorische Ökonomik' des Vereins für Socialpolitik vom 1. bis zum 3. Juli in Reisensburg, Günzburg, 2000
- "Classifying Technology Policy from an Evolutionary Perspective" at Jahrestagung von E.A.R.I.E. from 4th to 7th September in Turin, 2000
- "Innovation and Sectoral Employment – A Trade-off between Compensation Mechanisms", at Jahrestagung von EAEPE, "Integration and Inequality - Challenges for Institutional Economics" from 4th to 6th November in Prag (Tschechische Republik), Karls Universität Prag, 2000
- "Innovation Networks in the Biotechnology-Based Sectors" at meeting of the Atlantic Economic Association, from 12th to 17th February in München, 2001

- "Innovation Networks in the Biotechnology-Based Sectors" at International Conference on Complex Systems des New England Complex Systems Institute (NECSI) from 21st to 26th May, in Nashua (New Hampshire, USA)

- A. Pyka, P. Windrum, "The Self-Organisation of Innovation Networks",

- A. Pyka, P. Saviotti, "Industrial Sectors as Interacting Populations of Firms in Economic Development",

- A. Pyka, P. Saviotti, "Innovation Networks in the Biotechnology-Based Industries: From Translators to Explorers", at meting of the International J. A. Schumpeter Society vom 28. bis zum 1. Juli, in Manchester, "Change, Development and Transformation: Perspectives on the Innovation Process", 2001

- Jahrestagung des Ausschusses ‘Evolutorische Ökonomik’ des Vereins für Socialpolitik vom 13. bis zum 15. Juli in Reisensburg, 2001

- "Innovation Networks in the Biotechnology-based Industries- A Simulation Approach", at Workshop "Knowledge Transfer in Innovation Systems" am Max-Planck-Institute for Research into Economic Systems, Evolutionary Economics Unit vom 24. bis zum 26. August in Jena 2001

- "Twin-Peaks – What the Knowledge-based Approach can say about the World Income Distribution", at Jahrestagung des Vereins für Socialpolitik "Beschäftigung im vereinten Deutschland", vom 19.-22. September, an der Humboldt-Univesität zu Berlin, 2000

- "Innovationsökonomik", at Workshop "Was leistet die Ökonomie zum Verstehen von Innovationen", am 28. September, veranstaltet von Reson, Regionale Entwicklungsagentur für Südostniedersachsen und der Hans-Böckler-Stiftung in Braunschweig, 2001

- "The SEIN-Simulation Approach", at Workshop "Applied Simulation Analysis" vom 19. bis zum 20. Oktober an der Universität Augsburg, 2001

- "On the dynamics of interacting firm populations: from niche creation to mature markets", at Jahrestagung von EAEPE "Economics and Social Sciences: Complements, Competitors, Accomplices?", vom 2. bis zum 4. November am Wissenschaftszentrum Berlin (WZB) in Berlin, 2001

Paolo Saviotti
Conferences/Seminars

- EMAEE (European Meeting of Applied Evolutionary Economics) Grenoble 7-9 June, 1999

- DRUID Conference on Innovation Systems, Aalborg, 9-12 June, 1999

- "Self-Organization, Evolutionary Economics and Innovation, Theory, Modeling and Policy", University of Queensland, 12-15 July, 1999

- "Assessing the Potential of the Evolutionary Approach to Economics", Max Planck Institute for Research on Evolutionary Systems, Jena, 1-3 October, 1999

- EAEPE 1999, at the Charles University - Karolinum, Ovocný Trh, 3, Praha 1 - Staré Mesto (Old Town), Czech Republic, November, 1999

- "Knowledge, Complexity and Innovation Systems", Austrian Research Centres, Vienna, July 1 – 4, 2000

- INTERNATIONAL JOSEPH A. SCHUMPETER SOCIETY 8th ISS Conference, "Change, Development and Transformation: Transdisciplinary Perspectives on the Innovation Process", Manchester/UK, June 28-July 1, 2000

- 4th International Conference on Technology Policy and Innovation, Curitiba, South of Brazil, August 28-30, 2000

- "Arranjos e Sistemas Produtivos Locais e as Novas Políticas de Desenvolvimento Industrial e Tecnológico", Federal University of Rio de Janeiro, 4-6 September, 2000.

- The Sciences of Complexity: from Mathematics to Technology to a Sustainable World, ZIF, University of Bielefeld, October 6-12, 2000

- EAEPE Confernce, Berlin, 2-4 November, 2000.

Matthias Weber
Publications

- K.M. Weber: "The political control of large socio-technical systems: New concepts and empirical applications from a multi-disciplinary perspective", in: Williams, R./Russell, S. (eds.): New Concepts, Spaces and Policy Tools: Recent developments in Social Shaping Research, Edward Elgar, 2001

  Conferences/Seminars

- "The political control of large Socio-Technical systems: New concepts and empirical applications from a multi-disciplinary perspective", at the COST A4 workshop "Concepts, Spaces and Tools: Recent Developments in Social Shaping Research", Amsterdam, 11-12 November, 1999

- "Targeted construction or unintended emergence of networks? Innovation diffusion of CHP technology in different European countries", Presentation at the SEIN Seminar „Innovation Networks: Theory and Practice“, London, UK, 14 January, 2000

- "Innovation Networks: New Challenges for RTD Policies? Paper at SEIN Final Conference „Innovation Networks: Theory and Policy Implications“, Idefi, Sophia-Antipolis, France, April 19-20, 2001

- "The Role of Innovation and Policy Networks for Controlling Transformation Processes of Large Socio-Technical Systems. Combined heat and power during liberalisation in the UK, Germany and the Netherlands", at Spring meeting of Working Group "Politik und Technik" of the "Deutsche Vereinigung der Politikwissenschaftler DVPW", Konstanz, Germany, 15-16 June, 2001

- "Innovation policy for large socio-technical systems in transition: A conceptual framework and empirical evidence from the energy sector", Paper for the 5th International Conference on Technology Policy and Innovation, The Hague, Netherlands, 27-29 June, 2001

Janet Vaux
Conferences/Seminars

- "Policy texts, political outcomes" at seminar at PREST, University of Manchester, 2 March, 2000