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The University in the Learning Economy

by

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Abstract
In all parts of the world, universities are exposed to a growing pressure to change. This is caused by the emergence of new relationship between the economic dynamics and the production of knowledge as well as by policy and administrative initiatives finding their rationale in interpretations of these changes. In this paper an attempt is made to specify some of the new challenges, and suggest appropriate responses. Under the heading 'the learning economy' changes in the context of universities are identified.

One important conclusion is that traditional modes of organisation, characterised by sharp and rigid borders between disciplines and isolation from the society at large are being challenged and alternatives have to be developed. Another conclusion is that strategies of alliance and networking have become a key factor behind the success of universities. A third conclusion is that the universities' most significant contribution to society and the economy will remain well-educated graduates with critical minds and good learning skills.

Keywords: Production of knowledge, education, networks

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Introduction

In all parts of the world, universities are exposed to a growing pressure to change. This is caused by the emergence of new relationship between the economic dynamics and the production of knowledge as well as by policy and administrative initiatives finding their rationale in interpretations of these changes. In this presentation I will attempt to specify some of the new challenges, and suggest appropriate responses.

First, I will point to new insights in how knowledge is produced and utilised in the economy and how these provide new rationales for the public finance of research. One point that I will emphasize in that context will be revisited repeatedly in this presentation and that is *that knowledge cannot be reduced to information*. It will also be argued that to neglect this elementary fact gives rise to serious policy failure.

Under the heading 'the learning economy' we identify changes in the context of universities that follow from new dynamics in the economic sphere. The universities have become more directly involved in market-driven processes and more exposed to competition from other producers of knowledge. This occurs in a situation where knowledge production is characterised by increases in the degree of internationalisation and networking.

These changes in context pose new demands on the universities' contribution to competence building in society. The purpose of this presentation is to separate out what are necessary changes (e.g. connected to the need for lifelong learning) from merely fashionable demands for change (e.g. based upon overestimations of what information technology can do for knowledge production).

One important conclusion is that traditional modes of organisation, characterised by sharp and rigid borders between disciplines and isolation from the society at large are being challenged and alternatives have to be developed. Another conclusion is that strategies of alliance and networking have become a key factor behind the success of universities. A third conclusion is that the universities' most significant contribution to society and the economy will remain well-educated graduates with critical minds and good learning skills.

On the other hand, I will argue that as universities open themselves up, there is a need for changes in the institutional framework to ensure that the long-term, creative and critical aspects of academic research can survive. It is important also to consider the ethical and social dimension of universities' knowledge production in order to support the long-term viability of the learning economy. Merely to expose the universities to market processes is not tenable, neither for university nor for society.

On the basis of these considerations I point to the need for a strategy of diversification and differentiation of knowledge production, both internally, within university, and between different kinds of organisations engaged in knowledge production. This strategy becomes complex because of the need to maintain the unity of research and academic training. Still, this might be the only way to ensure

simultaneously interaction with, and rapid adaptation to the surrounding environment, on the one hand and the further development of the university's classical responsibility as a respected and reliable 'central bank of reliable knowledge' on the other hand.

Every university in the world faces these challenges, but they take on different forms from country to country. Here we exemplify and illustrate this development by discussing how Danish universities can and should act in the Danish Innovation System. A similar analysis of universities' role in the French Innovation System would point to other areas in particular need of reform and renewal. In both cases the production of graduates will remain the most vital contribution of universities to society and the economy.

The economics of knowledge production

The original argument for public financing of research was provided by economists who presented the output of knowledge production as 'information', i.e. as something that could be easily copied and reproduced by others, including competitors (Nelson 1959, Arrow 1962). Therefore scientific knowledge would not be provided to a sufficient extent by the private sector; a private firm would not have any incentive to invest in something that its competitors would get free access to. The outcome would be under-investment in research and a typical expression would be that the social rate of return on investment in research would be above the private rate of return.

The measurement of these benefits is charged with serious methodological problems, but international research indicates that the social normally exceeds private benefits from investments in research and development quite substantially (Lundvall in BETA working paper).

New rationales for the public support of research

Behind the rationale for the public support of research thus lies the understanding of knowledge as 'information'. More recent research on the production of knowledge demonstrates that significant parts of the knowledge vital to economic development takes the form of 'know-how' and competences, and these forms of knowledge do not lend themselves easily to 'codification' into 'information (Cohendet and Joly 2001). This knowledge has always tacit elements. This is illustrated by the fact that it is extremely difficult to transfer expert knowledge from human beings into software programmes without a change in the character of the competence takes place (Hatchuel and Weil).

This type of insight, implying that not all knowledge can be easily copied, does not weaken the argument for public support of research - a large part of the knowledge produced will be of such a general nature that it in all circumstances should be made available to as many as possible through education and other media. But it emphasises that the public research system has functions beyond supplying the private sector with new knowledge.

It is of vital importance that the public research system supplies both the public and the private sector with graduates and young researchers that have acquired *skills in systematic problem solving* that (perhaps after a period of learning from practice) are applicable in practice. The publicly financed research also plays an important role in the development of *new standards and scientific instrumentation.* Finally, it is vital to the domestic firms that they can find support from highly

developed research competence, since this is necessary to gain *access to foreign research results and technologies.*

From a linear to an interactive conceptualisation of innovation

The traditional understanding of 'knowledge as information' was combined with a 'linear' understanding of innovation processes where it was assumed that a rather straightforward conversion takes place from investments in basic science to economic growth, passing through applied science, technological development and marketing.

In the 80s, these assumptions were challenged both by theoretical developments and by empirical research. Today, there is general agreement among innovation scholars that one should rather regard innovation as an interactive process. All empirical studies show that a firm's interaction with suppliers, customers and knowledge institutions has become a necessary condition for successful innovation. New models of explanation stress the interaction between producers and users (Lundvall 1985) and that the interaction between scientific knowledge and technical innovation is characterised by complex feedback loops (Kline and Rosenberg 1986).

This means that investment in basic research will have different effects depending on how the linkages between firms and knowledge institutions have been shaped by history. It also means that the demand-side plays an important role for the development of knowledge and the innovations performed among producers. More specifically having excellent relations with demanding clients (lead users - see von Hippel 1988) may be seen as a decisive asset also for a research institution.

The relevance of these considerations has been further highlighted in the past few decades. The combination of growing complexity of the knowledge base and accelerated renewal and aging of knowledge (see below) entails that the positioning of firms and knowledge institutions in (often international) networks has become a vital factor for their relative success. It is no longer possible for an organisation regardless of size to rely solely on internal competence - IBM for example, is part of many co-operative efforts in product and technology development.

This pattern is occurring both in the realm of academic research and in the private sector. For groups of researchers, as for firms, it is increasingly vital to be part of attractive national and international networks. However it is essential to note that 'networking is working' - that is, the capacity to fulfil the obligations of co-operation is limited. For instance a group of researchers cannot enter into a multitude local relationships, without making international relations suffer – and vice versa. 'Close ties' are scarce for every agent and to structure and restructure them in such a manner that they support knowledge production is a major and difficult task for management and policy.

The Learning Economy

In the public debate knowledge is increasingly presented as the crucial factor in the development of both society and the economy. In a growing number of publications from the European Commission and OECD it is emphasised that we currently operate in 'a knowledge-based economy'. For several reasons I prefer the term 'the learning economy' in characterising the current phase of socio-economic development (Lundvall and Johnson 1994, Lundvall 1996)

The basic assumption behind this concept is very simple. The point of departure is that, working together, technological developments, globalisation and political processes of deregulation have led to an acceleration of the speed of technical and economic change. Consequently, access to any given knowledge base is less important for the economic success of firms and individuals, than their ability to *rapidly acquire new competences* as they get confronted with new types of problems. New knowledge is created at an increasing rate, but the quantity of business relevant knowledge is also being reduced as knowledge becomes obsolete at a faster pace than before.

This acceleration in economic change is reflected in different indicators. The life cycle of new products becomes shorter. New production processes are diffused more rapidly than before. For employees, work tasks change character, and many will change employer more often. In a report from the Danish Ministry of Education, a German study is cited, maintaining that it only takes one year from the exam, before half of what a computer engineer has learnt has become obsolete. The 'halving time' of what has been learnt in the education system is longer for other specific professions but on average, it is argued, it is about 8 years (Ministry of Education 1998, p. 56f.).

This is a strong argument for universities taking on permanent upgrading of candidates with an obsolete training as a major task. Life long learning has so far been a slogan with little real foundation in practise. In the learning economy it becomes a major challenge for universities and other institutions to make it a real phenomenon.

Information technology as a precondition for the Learning Economy

Information and communication technology is of crucial importance for the development of the learning economy. ICT accelerates many specific processes in knowledge production and knowledge application. It increases the power and speed of experimental *research processes*. Important phases of *innovation processes*, such as product design, testing and development will occur at an increasing pace. Finally the *feedback from market to production and product development* will also be speeded up. E-commerce will further reinforce this development.

Another essential consequence of the development in ICT is, that it changes the importance of distance. Today, networks - including networks of researchers, innovative networks and networks of production - can span continents more easily than before. But such ICT-networks do not replace personal contacts. ICT-connected networks can only be efficiently exploited and developed, when the people involved can meet face to face in order to exchange tacit knowledge, build codes of communication and establish mutual trust. Interaction with remote partners is still risky and costly. Only great potential gain or non-economic interests (curiosity for instance) will induce participation in such an interaction.

IT and the new possibilities for rapid long-distance communication have been vital for the development towards a learning economy. Basic economic mechanisms have been altered, and modes of knowledge production and transfer have been transformed. Both the total quantity of information and the amount of people with access to any given quantity of information has grown exponentially. This implies, however, that skills concerning the selection of relevant information and the intelligent use of it are increasingly in demand. Paradoxical as it may seem, the most important effect of the growth in the use

ICT has been that the building of competence and in particular the ability to renew competencies has become even more vital to personal, organisational and regional success.

The Virtual University? Some constraints on the use of Information and Communication Technologies in learning

Understandably, great expectations have been voiced both among policy makers and in the private sector as to the positive effects of ICT and the Internet in connection with learning and growth of knowledge. ICT is sometimes presented as a phenomenon that can completely replace human competence and interaction, through expert systems and Internet connections. The belief in this *myth* has proven costly for firms and public authorities. All systematic empirical and historical research shows that an acceleration in the diffusion of a radically new technology results in more harm than benefits if it is not combined with new institutions, new modes of organisation and new human competence. In a sense the wakening up from 'the new economy' dream illustrates this general phenomenon.

The most basic explanation of why ICT fails to fulfil the promises that some suppliers advertise is that information is not knowledge and that access to information is not learning. A system for information distribution can support learning processes but it certainly cannot replace human interaction, the central element in the acquisition of complex skills and competencies. Another problem particularly related to e-learning concerns the possibility of providing content that is meaningful and of high quality to the communication. It is for example very expensive to develop educational software, a particular problem for small language-areas.

In connection with the ambitious OECD-project 'Knowledge management in the learning society' (OECD 2000a), we engaged some of the leading pedagogical expertise in Silicon Valley in a discussion about to what extent computers could replace teachers in different learning processes. The optimism expressed was usually rather limited, and the experts stressed computer and network supported modes of learning as a marginal supplement to, rather than as a substitute for, conventional teaching. The examples of success typically involve students interacting with each other in between with being on-line through electronic media.

There are thus good grounds to be sceptical to *literal* interpretations of the term 'virtual university'. Exaggerated expectations will not be fulfilled and this might easily give a backlash, undermining the possibilities for a realistic and sensible utilisation of ICT in education.

Rate and character of learning

One interesting question is, whether a high rate of change influences the orientation and character of the learning and knowledge creation processes. As an illustration, we can look at how different types of research are prioritised in the learning economy. International statistics of research expenditure indicate that the private sector increasingly pursues research that will give immediate pay off, rather than basic and strategic research with a long horizon. This mirrors both the rapidity of the rate of change in the economy and changes in corporate governance that push toward a focus on short-term profits for shareholders. The large pension funds, and other institutional investors, which today are becoming the dominant owner interests, have less interest in developing lasting competence positions in specific

firms - they will typically use the exit opportunity should they find that the profit were insufficient in the short term (Chesnais and Serfati 1997).

At the same time, we can see how public research, both initiated at the national and at the EU-level, is linked to applied research programmes and gets channelled through new bodies where scholars have to make applications for specific projects. Within OECD resources for basic research grow slower than resources for applied research and development.

These tendencies illustrate some problematic aspects of the learning economy. When the speed is accelerating, there is less room for the search in depth and, generally, for critical reflection - and reflection remains a core element in any learning process. This mode of forced learning can be labelled 'intellectual strip-mining': rather work on the surface and follow already known intellectual trajectories, and get quick results, than risk that competitors might overtake.

The naïve criterion for productivity used in evaluating 'the excellence' of knowledge institutions, where the number of scientific publications is used as the single criteria for success, is pulling in the same direction. For instance in Denmark the single-minded use of this kind of evaluation criteria also on technological research has resulted in the fact that while no other country is as productive as Denmark in terms in scientific papers in technological research (measured per capita of the whole population) few other OECD-countries have so weak linkages between universities and industry. A similar syndrome appears to be present in the UK according to new data developed in the context of the benchmarking group led by Luc Soete.

Historically, the university has had room for slow and in depth learning, and been a place where one can keep a long-term perspective, and reflect critically both on theory and reality. One problematic aspect with the current development is that these traditional functions are undermined. Growing specialisation, combined with a demand for faster speed and a demand for a permanent and intense interaction with many external partners, does not leave much time for critical reflection. Instead it seems as if researchers increasingly are supposed to engage themselves as marketing experts. The scientist is expected to market himself, and his research group, to focus public attention on his own field of specialisation, point out the importance of his own projects, and stress the quality of the graduates he educates. Maybe, we might say, that the tearing down of the 'Ivory Tower' has resulted in scholars ending up in a somewhat stressful marketplace.

We should therefore consider, how we might introduce institutional solutions that would re-establish some of the *advantages* that were attached to the 'Ivory Tower'. There is more than ever a need for 'refuges' in society; places that give some room and time for slow, deep, and critical thinking, in contrast to the accelerating rate and mass production of more or less trivial articles published in periodicals.

Maybe the demand for 'slow and deep learning' will grow spontaneously in the future (in the same way as the growth of the fast-food industry has created a demand for 'slow food' in the culinary world). Globalisation, environmental degradation, the high-risk society and the growing split between those who are quick to learn and the others will gradually create a demand for institutions that aim at

understanding what goes on both in nature and society. If universities give up their ambitions in this field, privately owned and politically led think tanks would be ready to take over and impose their own bias on the analysis.

Universities are facing a difficult dilemma in the learning economy, and there is no simple answer to this dilemma. On the one hand, it is not sustainable to neglect real changes and political messages, signalling that there is a need for a growing interaction in a more rapidly changing world. There is a real need for strengthening interaction with the rest of society. On the other hand there is a need to ensure the long term, critical university based research. This Gordian knot might possibly be cut over with 'institutional differentiation' between, and within, institutions concerned with knowledge production and knowledge diffusion (Conceicao and Heitor 2001).

Such a differentiation should not have the purpose of separating the elite institutions from the rest. It should rather aim at a differentiation of functions. In addition, such a differentiation does not mean that there should be established a sharp division of labour between research, teaching and interaction with users. Given that the graduate production remains the most effective form of knowledge diffusion, it is important, that teaching and research do not get completely separated. The central unit in the well functioning university system is the team defined by a common field of research and sometimes by shared responsibilities for teaching. In this perspective, differentiation could mean flexibility in the use of time for the individual researcher, over the career, where there are periods of slow, in depth, research as well as periods of education and periods of intense interaction with external users of research. This might in the French case raise some questions about the CNRS-system where there has been a tendency to make scholars full time researchers for their lifetime.

Proficient learners and the others

The learning economy is characterised by new types of splits and inequalities. At first glance, proficient learners have an easy time in the learning economy. The learners with good basic communication skills, who are good at co-operation and fast at acquiring new skills, are in demand in the labour market. In particular, the so-called symbol analysts who have the ability to create order out of the confusion of complex and rapidly changing information, experience an almost insatiable demand that they can use to get high salaries, not least in the globalising part of the business sector.

Second, there is a category of employees that historically has experienced stability, and has had their pride in mastering a stable set of skills. Skilled workers and specialised academic professions are over represented in this group. They are now facing a great pressure in the direction of having to give up, what have been some of their core skills, and adopt new ones. The fact that British university scholars now belong to the most stressed and uneasy of all the professional groups in the UK has probably something to do with the evaluation wave in the English universities. A new type of learning that they cannot see as compatible with traditional academic ideals of working thoroughly and with reflection has been forced upon them.

Third, there are people who have a hard time to adopt new skills, because they have not, neither during their education nor through work experience, been able to establish the communication, co-operation, and learning abilities, required in most jobs today. This includes those unskilled workers who for years

have been working in routine jobs, where the demand for learning abilities has been too low. In a homogenous society, with very small income differences, as the Danish, people with a foreign background are especially vulnerable. There are few routine jobs left, and the requirements for communication and co-operation at the work place have become very demanding.

The learning economy will, if left on its own, polarise society by excluding those who cannot keep up with the accelerating speed from the ordinary labour market. This is in itself a serious problem for a society that gives a positive value to equality and solidarity. But it is also a problem in relation to the possibilities for maintaining effective learning in society. Learning is basically a social and interactive process. This implies among other things that the quality of learning will mirror the quality of human relations. This may be illustrated in different ways.

The social and the ethical dimension of the learning economy

A large part of all learning takes place in the daily interaction between people who are more or less experienced. This is the case for the young researcher learning research methodology in a co-operation with a senior scholar. It is also the case in business, where young economists and engineers are learning to become managers in an interplay with more experienced colleagues. Finally, it is obviously the case with apprenticeships, where master and apprentice interact in the formation of skilled workers. Actually, we find similar patterns in every area, where there is a need for developing skills and competencies. To read books, instructions and recipes may be an important element of the learning process, but to be good at performing tasks - including doing analyses and scientific work - you also need phases where the interactive and social aspect of the learning process dominate.

From this elementary observation it follows that relations between human beings are decisive for the quality of the learning that takes place. A minimum of trust is for example a precondition for effective learning. As far as the system of education contributes to a socialisation where students learn to behave 'ethically' (not to cheat and lie) it promotes learning in society as the whole. Reforms that come from above and that are not seen as legitimate of educational and research institutions, may undermine this social and ethical dimension. For instance, reforms that link individual remuneration to productivity may prove harmful in the long run since they tend to reinforce tendencies toward individualism and secrecy in research.

Social capital as a precondition for creation of intellectual capital

In a wider context this kind of problems have been discussed under the headline 'social capital'. Social scientists, sociologists and development researchers have ascertained, that different societies are characterised by having more or less difficulties functioning as a framework for a co-operation extending beyond the basic family units. (Coleman 1988, 1990, Putnam 1993, Fukuyama 1995, Woolcock 1998) Social capital is hard to measure, and several different definitions have been proposed. Looking at Russia of today, it is obvious what happens when social capital is not sufficiently present. In this case, there is access both to 'production capital' and 'intellectual capital', but in the absence of social capital, these resources have turned out to be of little social value. On the other hand, the most important explanation of the economic success of the Nordic countries (in spite of being small economies and specialised in so-called low tech product areas) is rich supply of 'social capital' (Lundvall and Maskell 2000).

It may seem paradoxical that the focus, increasingly, is put on ethical dimensions in private business, while at the same time the debate seems to be much less present at universities and knowledge institutions. Today the university debate on the ethical dimension is limited to criminal behaviour, such as plagiarism, and illegitimate experiments with human beings etc. A lack of an ethical basis for the knowledge production at the universities is especially problematic in a period where marketing and media related activities take up more and more of the attention of researchers and experts. An alternative would be that the universities' *development plans*; were built upon specific goals to contribute to solving global, national, and locally societal and ecological problems in fields, where the staff have special competence.

For instance, a goal of solidaric co-operation with universities localised in the poorer parts of the world could be made explicit and guide actual behaviour. One major problem with the globalising learning economy is the inherent tendency toward geographical centralisation. As globalisation develops universities in poor regions and countries tend to become more and more marginalized and excluded, seen in relation to the most dynamic networks of knowledge. As an illustration of professionals giving the ethical dimension a real meaning, one can look at how the organisation 'Médecins sans frontières' has gained respect among those who work within the field of health as well as in society in general.

The interface between university and industry

The interaction between universities and industry has for many years been a classical theme in OECD and other international organisations concerned with research policy. The background for the discussions has usually been the assumption that this co-operation is too weakly developed, and therefore needs to be stimulated. Often one has seen the universities' Ivory Tower-like character as the main cause of the lack of co-operation.

Recently the discussion has become intensified. During the last few years the argumentation has gone a step further, and today the universities are expected to contribute *directly* to the creation of new products and services. Behind this idea we find references to some of the new developmental trends that we have discussed above. But the most important fact is a specific development in the field of biotechnology, and related life science fields, where there has been a dramatic shortening of the time from scientific breakthrough to commercial use. Similar but somewhat less dramatic changes have taken place in the fields of software and communication technologies. New developments in the university-industry relationships in these fields in the US have increased the expectations to the contribution of European universities. In addition to teaching and research the universities now have 'a third task' with focus on their direct contribution to a more dynamic development of the business sector.

This discussion is to some extent about real phenomena, but it has a tendency to generalise from exceptions, and to use those exceptions as the basis for general strategies to change the universities. As we will show below it is neither realistic, nor sensible to try to make the 'whole industry' cooperate with the 'whole university'. There are certainly firms, especially within the pharmaceutical and software industry, that have a considerable interest in continuously cooperating with researchers at the university, but for most of the firms the most important link has to do with the recruitment of well

educated graduates. Correspondingly, at the universities, there are research groups that supply the industry with interesting results, but they constitute a minority among university researchers.

Only parts of the business community cooperate with parts of the university!
The rather limited interaction between universities and industry can be illustrated, both from the side of firms and from the side of universities. In the Disko-project we mapped the pattern of interaction in order to see to what extent Danish manufacturing firms cooperate with external partners when involved in product development. The analysis demonstrated that it is only a small part of all firms that co-operates with the universities.

While 60% of the product developing firms co-operate with Danish customers and suppliers, only 10 % co-operate with Danish universities. We will later come back to what are the decisive factors behind this weak level of co-operation. It should be noted here though, that the part of the industry that currently has documented interest in co-operating with the universities, seems to be quite small.

If we look at cooperation from the universities' point of view, it is striking, that the co-operation very unevenly distributed across different types of institutions and professional fields. An interesting mapping of financial resources used by Finnish university system shows that the technical universities have the largest part of their financing from private firms, and this part is about 10-12%. The normal contribution for the ordinary university is as low as 0-3%. If we look at disciplines and at the size of the *share of the externally financed research,* emanating from private firms (year 1998) the distribution is again uneven, with about 20% for engineering research and medical research, about 10% for the natural- and social sciences, and only about 1% for humanities (Nieminen and Kaukonen 2000).

It can be concluded that, so far, only a small part of the business world interacts with a small part of the university world. This implies, of course, that it would be dubious to design the organisation and regulatory frameworks of the universities, exclusively with reference to the new quite exceptional tendencies in the research fields of biotechnology and life sciences.

Danish universities in the national system of innovation
Most indicators show that Danish universities and Danish industry are less strongly linked, than in most other OECD countries. Private firms only contribute with a very low percentage of the higher education/institutions total research expenses in Denmark (number 24 out of 28 OECD- countries – see OECD 1999, page 32).

Survey data also show, showing that Danish firms co-operate less with the universities and research institutions, than firms in other similar countries do. This confirms results from other international comparisons. For instance, the OECD-report on the Danish research and innovation system noted that the linkages between firms and research institutions in Denmark were extremely weak (OECD 1995, page 138).

Table 1: Co-operation of firms with research institutions in connection with product innovation according to the size of the firm; in percentage.

	10-19	20-99	100+	All
Denmark				
Universities and Research institutions	9	16	31	17
Norway				
Universities	17	23	34	28
Research Institutions	32	41	56	48
Austria				
Universities	9	22	48	33
Contract research organisations	18	20	29	24

Source: Christensen, Gregersen and Rogaczewska (1999)

Table 1 confirms these observations. It compares the frequency of collaboration in connection with product innovation in Denmark with the frequency in Norway and Austria.

The weak university-industry has been an important issue in the industrial policy debate, and different ideas about how the activities of the Danish universities can be better integrated with, and utilised by the private sector have been put forward. The question is, however, to what extent the relatively low rate of Danish firms co-operation with research institutions constitutes a problem. To a certain extent, it reflects a typical Danish mode of innovation different from what you find in other countries. It is only after looking at the Danish innovation system as a whole that we can define what is the most appropriate role of the universities vis-a-vis the society and the economy.

The Danish innovation system

It is possible to demonstrate a specific Danish mode of innovation with its own characteristics concerning business structure, patterns of specialisation and the working of the labour market. This specific Danish way of innovation is reflected in the following observations:

- A majority of small firms and very few large firms, seen in an international context.
- A specialisation of production and exports dominated by products with a low content of R&D.
- Only 25% of the private firms have one or more employees with an academic training.

These characteristics should be combined with the fact that firms in most sectors, including so-called low technology sectors, appear to be quite innovative when it comes to products, processes and organisation. But the dominating form of innovation is local incremental adaptation of products. The innovations are rarely technically radical, and there are few Danish innovations that are new to the world market.

What is an innovation system?
The innovation system is constituted by organisations that, via their resources and activities, have an impact upon the speed and direction of the innovation processes and especially by the relationships between these organisations. The system may be characterised by its specialisation, by its institutional set-up, as well as by its connections to the rest of the world. Innovation systems are open systems, but they have a certain degree of autonomy in development, operation and specialisation (Lundvall 1999, s. 42).

In most Danish firms innovation is rooted in practice and experience based interaction between unskilled labour, skilled labour, technicians, designers and market oriented expertise. Competencies in the firms are often built by recruiting people with a broad experience established in a flexible labour market, and that there is intense inter-firm co-operation - especially with customer and supplier firms in Denmark and other countries.

This picture does not capture all parts of the Danish economy, however. In pharmaceuticals and life sciences the mode of innovation is extremely science based in Denmark. There are several historical reasons why Denmark is established at the very front in this area (Laursen 1996). In this specific area patents will to a very high extent cite new research results from private and public research laboratories. Since this field dominates the patenting taking place by Danish firms the OECD has been misled by their analysis of patents to conclude that there, also in general, is a very close connection between science and innovation in Denmark.

This is the context in which it has to be assessed if the particular Danish pattern, when it comes to co-operation between firms and universities, is satisfactory. It can be argued that it is natural that the Danish universities have been oriented towards the public sector rather than the private sector, because the private sector only to a limited degree has demanded inputs from science in the innovation process. However, historical small events might also have played a role. The fact that what constitutes the replica to Ecole Polytechnique in Denmark, from the very beginning (1829), established a stronger orientation towards academic natural science than similar institutions founded elsewhere, may have influenced the Danish university system as a whole.

Another question is whether parts of the Danish private sector, e.g. the pharmaceutical industry and parts of the electronic industry, which do need continuous co-operation with the research institutes, have any problems at all in establishing co-operation with scientists at the universities. The problems formulated by representatives from this kind of industries, are usually more linked to whether universities can deliver a sufficient number of candidates to rapidly expanding research-intensive firms.

The division of labour among firms, technological service institutes and universities

Another factor that has to be taken into account is the technological advisory system that has been developed in Denmark, such as the GTS-institutes (GTS=state recognised technological service) and private management consultant firms, which to a certain act as bridge builders between science and business. It would be problematic to consider the interaction between universities and industry without

taking the role of this advisory system into account. Ideally, a strategy for science and innovation policy should include all these three main components of 'the innovation system in its narrow sense'.

The GTS-institutes and consultancy firms, have a central function as transmitters of established as well as more recent scientific knowledge and they make it possible for a broader set of users to adopt it and put it into practical use. They work under circumstances more similar to the private sector clients and this eases the communication. In this respect they differ from universities that neither can nor should be transformed into purely market oriented private firms. In some instances it may be more appropriate to strengthen the scientific competence of the technological advisory system than to reinforce commercial aspects of the academic system.

As pointed out, however, in some scientific fields the frontiers between basic research, applied science and commercial use now tend to become increasingly fuzzy. What is at least as important is that there is a general tendency toward a growing importance of science based and formalised knowledge for competitiveness in more traditional product areas. It would therefore be an advantage if firms could get more easy access to an interaction directly with the science institutions. Within the most advanced areas, a strengthened interaction would even be useful for the universities since it would promote basic research. This would be the case when the private sector is leading the development and use of for example expensive advanced instrumentation. But it remains important to keep a focus on the production of graduates and the development of the human resources.

Human resources are also the key to networking

Over the last decade there have been several new innovation policy initiatives in Denmark giving public support to new modes of co-operation such as:

- Co-operation contracts - bringing firms, technological institutes and universities together in common projects.
- Innovation environments – establishing more permanent local collaboration.
- The Mobility program and the Industrial researcher agreement – aiming at creating more mobility between university and industry.

All these initiatives aim at overcoming barriers between 'the three worlds'. Especially the last mentioned might be seen as important instruments. Different analyses in the DISKO-project (the project on the Danish Innovation System in a Comparative Perspective) point to human resources, as the most important underlying element of the innovation system. This is not merely a question of competence in the labour force, but it also refers to the interaction and network formation between the different parts of the system. This can be illustrated by combining labour market data with survey data on industry-university connections.

In table 2 firms with less than two academic employees are compared with firms where a larger number of the employees have degrees from higher education. Table 2 shows, not surprisingly, that large firms have intensified their co-operation with science institutions more frequently than smaller firms (26% of firms with more than 50 employees versus 11 % of the smaller ones have cooperated with these institutions). However, and more interestingly, the table shows that there is a difference between firms

reflecting the presence of employees with higher education. For small firms the probability of intensifying the co-operation with a science institution is twice as high when the business has more than 2 employees with higher education.

Table 2: Share of firms that have strengthened their co-operation with knowledge institutions divided by size of the business and amount of employees with higher education (HE) - Percentage that have cooperated in connection with product development.

	49 employees or less			More than 49 employees		
	HE>2	HE<2	All	HE>2	HE<2	All
Increase in co-operation	19	9	11	35	24	26
No increase in co-operation	81	91	89	65	76	74
Total	100	100	100	100	100	100

Source: Nielsen 1999

On this background, it should be considered to support a new version of the so-called 'icebreaker' program, making it attractive for private firms to hire an academically educated person. In the earlier versions the major rationale was labour market related but such programs also have a great potential when it comes to promote innovation. They contribute to a change in the mode of innovation in small and medium sized firms giving them more direct access to the kind of knowledge available at science institutions.

Another means to strengthen the interaction between the worlds of science, consultants and business is programs promoting mobility between these worlds. There is a need to review the incentive systems shaping the careers so scientists as well as the predominant research evaluation principles. Experiences from other countries, and especially from Stanford University, that has been among the most successful in promoting this kind of mobility, demonstrate that barriers are substantial and that very strong incentives are necessary to get the process started. One possibility would be to give universities room for local experimentation with central support to see which instruments are the most efficient.

Organisational learning as part of building of competence

In the previous parts I have emphasised the exchange of knowledge taking place between university and industry. We have illustrated that the connections are weak in Denmark. We have at the same time illustrated that the distribution of candidates is an important factor in this connection. We will now change the focus toward how competence development within the firms may be promoted by strengthening their ability to engage in organisational learning and what new demands the university will be confronted with in this context.

In table 3, we compare the development in employment for employees with a higher education and workers without specific education in two extreme types of Danish firms. 'Dynamic firms' are firms active in terms of product development and in using management techniques promoting organisational learning, while 'static firms' are passive in both these respects.

Table 3 shows three interesting tendencies. The first is that dynamic firms initially have a considerably larger presence of academics than static ones (there is 1 academic for every 15 unskilled worker among the dynamic firms and 1 for every 40 among the static ones). The second tendency is that both types of firms increasingly employ people with higher education during the period of study. The third tendency is that there is no clear indication that dynamic firms should be increasing the intensity in their use of academic labour more rapidly than the static ones.

Table 3: Development in employment for graduates and for unskilled labour in dynamic and static firms 1990-94 – aggregate numbers from 2000 surveyed Danish firms in the private sector.

	Nov. 90	Nov. 91	Nov. 92	Nov. 93	Nov. 94
Higher education employees					
Dynamic firms	2 363=100	105,3	110,0	114,1	125,9
Static firms	329=100	94,8	107,3	115,5	121,3
Unskilled labour					
Dynamic firms	30 753=100	98,0	93,5	88,4	94,2
Static firms	11 949=100	96,7	96,1	89,8	92.1

Source: Nielsen 1999

There is nothing in these data that indicate that a movement in Danish firms toward more developed organisational forms would weaken the position of unskilled labour. The demand for formal qualifications seems to be increasing at about the same rate in static and dynamic firms. Further analyses have shown that the job loss of unskilled workers take place mainly in the firms exposed to increasing competition that do not engage in technical and organisational change (Lundvall 2002).

Skill requirements and organisational change - new challenges for the universities

Since the main contribution of universities to the development of the private sector is to educate and provide qualified labour, it is important to capture new tendencies in skill and competence requirements. In this section we are going to take a closer look into how management in a selection of Danish firms refer to changes in the content of work in the 90s. The changes referred to below are general and do not refer to academic labour in particular, but as it is pointed out in analyses of national competence development by the Danish Ministry of Education other international surveys reveal a high degree of similarity in skill demand trends across different types of labour (Ministry of Education 1998, p 30). It is of particular interest to focus on changes in the competences demanded within firms that have engaged in organisational change (Gjerding 1997).

One of the results from the DISKO-surveys is that organisational change often is combined with new demands for qualifications. Table 4 reveals substantial differences in the pattern of answers between the firms that have introduced new forms of organisation and those that have not. The importance of general skills reflected in growing demands for independence in the work situation, co-operation with external partners, especially customers, and for co-operation with management and colleagues, have grown remarkably in firms that have made organisational changes and much less so in firms that have not changed their organisation. There are correspondingly large differences between the two types of organisation in the rate of occurrence of a reduction in routine work.

Table 4: Changes in task content for employees in the period 1993-95 for firms that have made organisational changes (outside the parentheses), compared with firms that have not made organisational changes (in parentheses).

	More	Less	Unchanged	No answer
a. Independence of work	72,6 (37,1)	4,2 (2,7)	21,2 (56,3)	2,0 (3,8)
b. Professional qualifications	56,4 (36,3)	7,5 (5,3)	33,3 (53,8)	2,8 (4,4)
c. Degree of specialisation	33,9 (26,2)	20,8 (7,8)	39,3 (58,4)	6,0 (7,5)
d. Routine character of tasks	5,6 (8,2)	41,8 (15,5)	45,0 (67,1)	7,7 (9,1)
e. Customer contact	51,6 (29,3)	5,1 (3,1)	37,2 (59,9)	6,1 (7,6)
f. Contact with suppliers	34,9 (18,0)	7,1 (4,3)	46,4 (62,0)	11,6 (15,6)
g. Contact with other firms	24,7 (14,0)	5,5 (4,3)	56,8 (68,9)	13,0 (13,7)
h. Co-operation with colleagues	59,1 (27,1)	5,8 (4,5)	31,8 (63,3)	3,2 (5,0)
i. Co-operation with management	64,9 (28,6)	5,9 (4,2)	26,1 (62,2)	3,1 (4,9)

Source: Voxted 1999, DISKO-Survey, N=952 (981)

All firms, and especially those that engage in organisational change require from the experts they hire that they can communicate and collaborate internally and externally. This implies that the teaching at the universities needs to be adjusted in order to prepare the students for communicating and co-operation with experts from other disciplines. Firms that are change oriented are at the same time asking for both more and less specialisation. This may be seen as an argument in favour of a differentiation in teaching methods at the different universities. The ideal team for a development task is perhaps a combination of engineers from respectively the more discipline-oriented Technical University of Denmark and the problem based learning-oriented Aalborg University.

In general, it might be a good idea to maintain the existing differentiation among Danish units of higher education. There are considerable differences between the different universities when it comes to size, academic profile, pedagogical philosophy and structure. These differences are typically rooted in historical incidents related to the time of creation of the institution. This kind of differentiation may be difficult to cope with for employers who hire graduates. It might also be regarded as a nuisance by civil servants in the Ministries of Finance, wanting to simplify the benchmarking of universities. On the other hand the differentiation may prove to be a crucial asset in a complex and changing world. It gives the system an ability to readjust and respond to the complex and differentiated emerging social and economic needs.

What universities can do to support the learning economy

Burton Clark is a spokesman for 'The entrepreneurial university' (Clark 1998). While the analysis might be too focused on fund-raising the idea of universities taking the initiative is certainly attractive. The alternative would be a rather hopeless nostalgic defence for 'paradise lost' – universities would easily end up as victims and in a squeeze between the extension of centralized technocratic styles of management on the one hand and privatisation and market forces on the other.

The initiative of the former Danish government to ask each university to develop its own development plan with a specification of goals and of the instruments to reach this goal is quite laudable in this respect.

Such a development plan would typically take into account and plan for:

- Positioning of basic functions in relation to other Danish and foreign universities.
- Making explicit basic values and reflection on how to make these values come to work in the context of scientific work and teaching.
- Specifying the division of labour and alliances with other knowledge institutions in Denmark (cultural institutions, GTS-institutes, professional training institutions, private knowledge intensive service firms).
- Positioning the activities in regional, national and international scientist networks. Typically this will take place at the level of research teams, but management may contribute with positive incentives and support.
- Differentiation of the organisation of the university, that makes it possible to cover basic research needs as well as an interaction with new categories of users of research and training. (Spanning from interdisciplinary centres of advanced learning, with room for 'deep' learning, to network centres and information services that inform small and medium sized firms about where they can find relevant academic knowledge).
- Definition of key functions combined with out-sourcing of peripheral activities, and particularly those activities that have a negative impact on the main task of the universities, i.e. to educate qualified candidates.
- Analyses of internal routines and of the micro organisation in order to relieve teachers and scientists from trivial tasks and give more time for scientific work and teaching.
- Introduction of a structure of incentives and evaluation principles that ensures the balance between teaching involvement, scientific work and interaction with the outside world. Taking into account that university scholars are more susceptible to incentives such as more time for basic research and common acknowledgement than individual economic incentives.
- Pedagogic renewal in order to prepare the students for the learning economy, where interdisciplinary, problem solving, co-operation and communication is emphasised. Increase in practical activities can strengthen the learning and ease the transformation to the labour market.
- Development of a systematic system for life-long learning for their own graduates and for others who need an upgrading of their competences

The Danish university system is, according to the OECD report 'Education at a Glance', more under financed than comparable systems in other OECD countries with a similar level of income (OECD 2000c, p. 89). According to these calculations, Denmark uses half the resources per university student as compared to the US and 2/3 as compared to Sweden. This raises the question: Why do politicians in Denmark give such low priority to higher education?

A positive scenario for the near future could be that the Ministry of Science and Technology now fully in charge of Danish universities, guaranteed a gradual 'normalisation' of the financial situation of universities and that the universities, as their response, at the same time engaged in gradual but ambitious processes of institutional change to fulfil their part of a mutual contract.

The management of universities has a great responsibility for making this dream come true. Their main tasks are nothing less than to stimulate the renewal of the university culture and not least to create a more efficient management. In this context they should perhaps learn from modern business management, about storytelling, ethics and the role of business culture, rather than just focus on about benchmarking and quantitative evaluation procedures.

Literature:

Arrow, K. (1962), 'Economic welfare and the allocation of resources for invention', in *The rate and direction of invention*, Princeton, Princeton University Press.

Bourdieu P. (1977) 'Cultural and social reproduction', in Karabel, J. and Halsey, H.A. (eds.) *Power and Ideology in Education*, New York: Oxford University Press.

Chesnais, F. and Serfati, C. (1997):'Long horizon investment under a globalised finance dominated accumulation regime: an interpretation of the levelling off and decline of R&D in the 1990s', Paper presented at the *DRUID Summer Seminar on Competition and Industrial Dynamics*, June 1-3, 1997, Skagen.

Christensen, J.L., Gregersen, B. og Rogaczewska, A. (1999), *Vidensinstitutioner og innovation*, DISKO-projektets rapport nr. 8, København, Erhvervsudviklingsrådet.

Clark, Burton R. (1998) *Creating Entrepreneurial Universities,* Guildford: IUA Press, Pergamon.

Coleman J. (1988) 'Social Capital in the Creation of Human Capital', *American Journal of Sociology*, 94(Supplement) pp. 95-120.

Coleman J. (1990) *Foundations of Social Theory*, London: Harvard University Press.

Cohendet, P. and Joly, P.-B. (2001), 'The production of technological knowledge: New issues in a learning economy', Archibugi, D. and Lundvall, B.-Å. (eds.), *Europe in the Globalising Learning Economy*, Oxford Unversity Press, 2001.

Conceiçao, P. and Heitor, M. (2001), 'Universities in the Learning Economy: Balancing Institutional Integrity with Organisational Diversity', Archibugi, D. and Lundvall, B.-Å. (eds.), *Europe in the Globalising Learning Economy*, Oxford Unversity Press.

David, P. (1991), 'Computer and dynamo: The modern productivity-paradox in a not-too-distant mirror', *American Economic Review*, Vol. 90, No. 2.

Drejer, I. (1998), *Den vidensbaserede økonomi*, DISKO-projektets rapport nr. 4, København, Erhvervsudviklingsrådet.

The Economic Council (1997), *Dansk Økonomi Forår 1997*, København, Det Økonomiske Råd.

Fukuyama, F. (1995), *Trust: The social virtues and the creation of prosperity*, London, Hamish Hamilton.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. and Trow, M.(1994), *The New Production of Knowledge*, London, Sage.

Gjerding, A.N. m.fl. (1990), *Den forsvundne produktivitet*, København, JØFs forlag.

Gjerding, A.N. (red) (1997), *Den fleksible virksomhed*, DISKO-projektets rapport nr. 1, København, Erhvervsudviklingsrådet.

Government (2000), *dk21 - Regeringens erhvervsstrategi*, København, Regeringen.

Hicks, D. (1995), 'Published papers, tacit competencies and corporate management of the public/private character of knowledge', *Industrial and Corporate Change*, Vol. 4, No. 2.

Kline, S.J. and Rosenberg, N. (1986), 'An overview of innovation', in Landau, R. and Rosenberg, N. (eds.), *The Positive Sum Game*, Wash. D.C., National Academy Press.
Laursen, K. (1996), 'Horizontal diversification in the Danish national system of innovation: The case of pharmaceuticals', Vol. 25, No. 7.
Lundvall, B.-Å. (1985), Product innovation and user-producer interaction, Aalborg, Aalborg Universitetsforlag.
Lundvall, B.-Å. (1996), 'The Social Dimension of the Learning Economy', *DRUID Working Paper*, No 1, Aalborg University, Department of Business Studies.
Lundvall, B.-Å. (1999), *Det danske innovationssystem - et forskningsbaseret debatoplæg*, ErhvervsfremmeStyrelsen, København, 1999.
Lundvall, B.-Å. and Borrás, S. (1997), The globalising learning economy: Implications for innovation policy, Bruxelles, TSER-DG XII European Commission.
Lundvall, B.-Å. and Johnson, B. (1994), 'The learning economy', i *Journal of Industry Studies*, December.
Lundvall, B.Å. and Maskell, P. (2000), ' Nation states and economic development - From national systems of production to national systems of knowledge creation and learning', Gertler, M. et al (eds.), Geographical Handbook, Oxford, Oxford University Press.
Madsen, P.T. (1999), *Den samarbejdende virksomhed*, DISKO-projektets rapport nr. 6, København, Erhvervsudviklingsrådet.
Ministry of Education (1998), *National kompetenceudvikling*, København, Undervisningsministeriet.
Nelson, R. R. (1959), 'The simple economics of basic scientific research' *Journal of Political Economy,* Vol. 27, no. 3.
Nieminenm M and Kaukonen, E. (2000), Universities, knowledge based economy and networking, paper presented at SITRA seminar in December 2000, stencil.
Nielsen, P. (1999), *Personale og fornyelse: Menneskelige ressourcer i den nationale innovationssystem*, DISKO-projektets rapport nr. 7, København, Erhvervsudviklingsrådet.
OECD (1999), *The knowledge based economy: a set of facts and diagrams*, Document presented at the 1999 Ministerial meeting on science and technology policy, Paris, OECD.
OECD (2000a), *Knowledge Management in the Learning Society*, Paris, OECD.
OECD (2000b), *A new eonomy? The changing role of innovation and information technology in economic growth*, Paris, OECD.
OECD (2000c), *Education at a glance*, Paris, OECD.
Polanyi, M. (1958/1978), *Personal Knowledge*, London, Routledge & Kegan.
Polanyi, M. (1966), The *Tacit Dimension*, London, Routledge & Kegan.
Putnam, R.D. (1993), *Making democracy work - civic traditions in modern Italy*, Princeton, Princeton University Press.
Von Hippel, E. (1988), *The sources of innovation,* Oxford, Oxford University Press.
Voxted, S. (1998), *Efteruddannelsessystemets rolle og muligheder i det danske innovationssystem*, DISKO-projektets rapport nr. 3, København, Erhvervsudviklingsrådet.
Wagner, M.F. (1998), *Det polytekniske gennembrud*, Aarhus, Aarhus Universitetsforlag.
Woolcock, M. (1998), 'Social capital and economic development: toward a theoretical synthesis and policy framework', *Theory and Society*, No. 2, Vol. 27, pp. 151-207.

Danish Research Unit for Industrial Dynamics

The Research Programme

The DRUID-research programme is organised in 3 different research themes:

- The firm as a learning organisation
- Competence building and inter-firm dynamics
- The learning economy and the competitiveness of systems of innovation

In each of the three areas there is one strategic theoretical and one central empirical and policy oriented orientation.

Theme A: The firm as a learning organisation

The theoretical perspective confronts and combines the resource-based view (Penrose, 1959) with recent approaches where the focus is on learning and the dynamic capabilities of the firm (Dosi, Teece and Winter, 1992). The aim of this theoretical work is to develop an analytical understanding of the firm as a learning organisation.

The empirical and policy issues relate to the nexus technology, productivity, organisational change and human resources. More insight in the dynamic interplay between these factors at the level of the firm is crucial to understand international differences in performance at the macro level in terms of economic growth and employment.

Theme B: Competence building and inter-firm dynamics

The theoretical perspective relates to the dynamics of the inter-firm division of labour and the formation of network relationships between firms. An attempt will be made to develop evolutionary models with Schumpeterian innovations as the motor driving a Marshallian evolution of the division of labour.

The empirical and policy issues relate the formation of knowledge-intensive regional and sectoral networks of firms to competitiveness and structural change. Data on the structure of production will be combined with indicators of knowledge and learning. IO-matrixes which include flows of knowledge and new technologies will be developed and supplemented by data from case-studies and questionnaires.

Theme C: The learning economy and the competitiveness of systems of innovation.

The third theme aims at a stronger conceptual and theoretical base for new concepts such as 'systems of innovation' and 'the learning economy' and to link these concepts to the ecological dimension. The focus is on the interaction between institutional and technical change in a specified geographical space. An attempt will be made to synthesise theories of economic development emphasising the role of science based-sectors with those emphasising learning-by-producing and the growing knowledge-intensity of all economic activities.

The main empirical and policy issues are related to changes in the local dimensions of innovation and learning. What remains of the relative autonomy of national systems of innovation? Is there a tendency towards convergence or divergence in the specialisation in trade, production, innovation and in the knowledge base itself when we compare regions and nations?

The Ph.D.-programme

There are at present more than 10 Ph.D.-students working in close connection to the DRUID research programme. DRUID organises regularly specific Ph.D-activities such as workshops, seminars and courses, often in a co-operation with other Danish or international institutes. Also important is the role of DRUID as an environment which stimulates the Ph.D.-students to become creative and effective. This involves several elements:

- access to the international network in the form of visiting fellows and visits at the sister institutions
- participation in research projects
- access to supervision of theses
- access to databases

Each year DRUID welcomes a limited number of foreign Ph.D.-students who wants to work on subjects and project close to the core of the DRUID-research programme.

External projects

DRUID-members are involved in projects with external support. One major project which covers several of the elements of the research programme is DISKO; a comparative analysis of the Danish Innovation System; and there are several projects involving international co-operation within EU's 4th Framework Programme. DRUID is open to host other projects as far as they fall within its research profile. Special attention is given to the communication of research results from such projects to a wide set of social actors and policy makers.

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