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Anders Ekeland and
Finn Ørstadvik

The Technologists in the Innovation System - The role of human mobility

Anders Ekeland and Finn Ørstadvik
STEP
Hammersborg torg 3
N-0179 Oslo
Norway

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Studies in technology, innovation and economic policy
Studier i teknologi, innovasjon og økonomisk politikk

Hammersborg torg 3, 0179 Oslo, Norway
Telephone +47 2286 8010
Fax +47 2286 8049
http://www.step.no/

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Chapter 1. General introduction

This paper is written as part of the research programme “FAKTA”, a large scientific programme with the aim of increasing the knowledge base for Norwegian research and innovation policy. The paper is part of the FAKTA project “Competencies, mobility and value creation”.

Other papers from this project analyse researcher mobility, the structure of competencies of firms and the distribution and mobility of ICT-educated persons.

This particular paper is in many ways parallel to the paper on ICT-educated persons but it looks at all persons with a mathematical, technological and other natural science educations as a whole. It also takes a closer look at the engineers since this type of education is seen as especially relevant for the innovative capacity of firms, sectors and consequently the national economy. There is no way that one from the educational classification itself can distinguish engineers, so using the title of the educations does this. Since the title “engineer” is fairly well standardised this should capture most of the “real” engineers, i.e. persons having an engineering type of education. Again it is the ITC educations that are most problematic since these educations – often being associated with mathematics or physics at the universities – often do not use the word engineer. At least this is not done in the education statistics, probably reflecting that Norwegians use the title “programmer” and only very seldom “software engineer”.

Given the explorative character of this work, mapping the stocks and mobility of natural science educated persons, problems of statistical classification that might be very decisive for more precise policy oriented analysis is less acute in this context.

First we have a more general discussion of natural science educated persons, with a focus on engineers. The term “engineer” is here used in a broad sense namely people with a higher natural science education, not explicitly concerned with basic research, practically speaking everyone who is not employed at universities. This general discussion of engineers is focussed on the non-market networks, the professional networks. The logic behind this discussion is that there is probably a trade off between the knowledge flows done by human mobility and the knowledge flows mediated by professional networks – formal and informal.

Then we move on to discussing mobility and knowledge diffusion, the Canberra Manual, the educational classification of technologist. We take a look at the stocks of technologists before looking at mobility and finaly mobility in relation to R&D intensity of industrial sectors.

Chapter 2. Technologists in the innovation system – the role of networks and mobility - some theoretical reflections

2.1 Introduction

Nearly everyone is rather confident in knowing what a technologist is, and most people would agree technologists are important people in modern economies. Still, when a sociologist must give a clear and unequivocal – scientific – description of who the technologists actually are, what they do, and why they are important, he may find this unexpectedly difficult.

First, because many concrete examples may be difficult to classify. (Is a university lecturer with expertise in the field of programming a technologist? Can a person with a two-year technical education practicing as a consultant on fire-protection of buildings be termed a technologists? And what about a skilled worker in a plant producing advanced machinery, is she a technologist?)

Second, there is the question about significance. Obviously, technology is important in modern societies. Our lives and our businesses are crammed with technically advanced tools, gadgets and devices. Everyone contributing to this, to what we could call the technical dimension of society, or the technical domain, are clearly important. But are those we like to call *technologists* more important than others? Do technologists play a particularly significant role with respect to innovation? And is it really the case that the mobility of technologists matters for a society's ability to generate economic growth and societal development?

All these are questions we wish to address in this chapter.

2.2 Who are they and what do they do?

In spite of the complexities of real world technically related functions and occupations, we can of course provide a simple, general, and approximate answer to the questions who technologists are and what they do. We would do this by saying that technologists are those that have intimate knowledge of technology, and who design technology, develop it, or produce it. Faced with critical opponents, we would then most probably be encouraged to reflect on our use of the term "technology". What is technology, exactly? We may, however, manage to answer also this question in a quite simple and straightforward manner. We can simply point at the plethora of technical devices and systems around us in our daily life and say: "That is technology!" Cars, computers and computer programs, trams, planes, weapons, building construction sites, kitchen appliances, mobile phones, all kinds of other electric and electronic devices, and so on, and so forth. All those things are examples of – or *embody* – technology, and the people designing and developing these products, and the systems by which they are fabricated, we should consider to be technologists.

A mapping of this kind would be labour intensive, but should in principle not be difficult to carry out. However, all this might not actually be very helpful for making us able to answer the questions raised above, whether this or that type of specific technical person should be called a technologists. And it would appear that the difficulties we perceive are connected primarily to two things: Our wish to make a distinction between scientists and technologists on the one side, and between technologists and technically skilled workers (technicians) on the other side.

Looking at all the people who know, design, develop and produce technology, some we will not want to label as technologists because they work in academic institutions, and with abstract models and laboratory research that result in papers, rather than devices. Still, what they do may be intimately related to technology, and the dividing line that supposedly distinguish a scientist from a technologist may be non-existent other than as a rather arbitrary or sociological concept imposed on reality by us, the analysts, for convenience reasons.

In a similar vein, the dividing line drawn between technicians and technologists may be argued to be a highly arbitrary one. In this case, it may be that the primary reason for making the distinction would not be analytical, nor the result of disinterested efforts to portray reality in a realistic and true way, but related to social divisions and interests. The conceptual distinction would appear in essence to reflect a striving for social distinction: Diverse groups of people engaged in designing, developing and producing technical artefacts and systems compete for scarce “social capital” by insisting on a distinction being made between the technical and the technological. We are, obviously, referring here to the French sociologist Bourdieu’s interpretation of *the distinction*, as a weapon used by ambitious social groups’ in their striving to achieve superiority in terms of prestige, wealth, power or class.[1]

But is this interpretation at all warranted? Isn’t the really interesting, underlying issue here one related to real structures of knowledge, competence and formal education, rather than to petty rivalry over vested interests? Against this, the non-compromising Bourdieu devotee would no doubt argue that the competition over scarce resources almost without exception will be carried out in ways that obscure the reality of underlying, vested interests. It is exactly because of this, he would argue, that the primary method to obtain the desired distinction is based on the leverage of higher education, either referring to the specific institution (“Yale”), type of institution (“University”), or length of education (“years of study”).

Albeit admitting a relevance to the conflict point of view of Bourdieu, we wish to emphasise different aspects of the issues involved. It appears to us that the patterns of formal education, the distribution of technological competence, and the social relations of knowledge generating systems have a deeper significance than what is apparent in the analysis developed by Bourdieu. We will return to this point shortly.

[1] Bourdieu 1984.

At this point, what we want to do is to show how one can use education as a means to give one specific type of answers to the questions concerning what technologists are and what they do. Later in the report we will draw a map of the stocks of technologists that are found in a modern society by employing technical means provided us by statistics. More specifically, we will use the Standard of Educational Statistics, to categorize technologists of different kinds, and comprehensive register data containing education and career data for the entire Norwegian population, to show where in the economy they are located, and how they move.

The Norwegian classification of education (NUS) is a variant of the international standard for education statistics (ISCED 1997). We wish to develop analyses where the length of education is one variable, and the type of education is another. We then use formal education as a proxy in order to do a mapping of stocks and flows of technologists. We use type of education and the length of education to distinguish various types of technologists.

The details of the statistical classification we use are presented elsewhere in this report. On the basis of such a classification, however, we can state quite succinctly *who* the technologists are *for us, in this report*: They are people with 1-2 years, 3-4 years and 5 or more years of education in the engineering, manufacturing and construction, that is in:[2]

- Engineering and engineering trades
  - Engineering and engineering trades (broad programs)
  - Mechanics and metal work
  - Electricity and energy
  - Electronics and automation
  - Chemical and process
  - Motor vehicles, ships and aircraft
- Manufacturing and processing
  - Manufacturing and processing (broad programs)
  - Food processing
  - Textiles, clothes, footwear, leather
  - Materials (wood, paper, plastic, glass)
  - Mining and extraction
- Architecture and building
  - Architecture and town planning
  - Building and civil engineering

2.3 The social and economic significance of technologists

Having answered at least in a preliminary way a question concerning *who* technologists are, we for now pass over the details concerning the composition of the stock of technologists that are in Norway, and what the sectoral distribution of technologists might be. This will be elaborated later in the report. Rather, we will concentrate attention on what it is in principle that makes technologists significant in the economy, and important with respect to innovation, in particular.

[2] As will be pointed out later, the Norwegian classification is somewhat different than the one used here.

The handling of the elements of the technical in a society, the machines, the apparatus, the materials and the processes that are involved in value creating activities, in other words in human work, is the functional domain of technologists. By knowing how technical devices work and how they are made, technologists play an absolutely decisive role for the operation of any modern society. Most activities in modern societies depend fundamentally on the functioning of complex man-made artefacts. Knowledge is embodied in such artefacts: They could neither be maintained nor made without a complex and wide-ranging set of technological knowledge.[3] Therefore, people with technological competencies are important both for the day to day operations of societies, as well as for the development of societies over time. Engineers and technologists build, maintain and upgrade essential parts of the socio-technical systems that in a tangible way constitute societies.

It is essential to note how there are *two main aspects* of this function: One is related to the maintenance and the day-to-day operation of the technical domain. The other is related to the furthering of the technical domain; to development and to technological innovation.

The first aspect of the function of technologists in the technical domain, system maintenance, is static and oriented towards sustaining working systemic equilibriums. This at times involves extending and further developing a system for better effectiveness and efficiency. Taking care of this task means to be a master of system optimisation and to understand how to balance costs with benefits. The second aspect of the technologist's mission, however, is very different. This task is dynamic and evolutionary. It is fundamentally system transgressing. It is also creative and contains an important element of unpredictability. It is performed on the basis of technological competence and technical skills, but it is fundamentally a learning process, and when it is successful, the outcome could not have been projected from the earlier state of affairs.[4]

It would appear that the former function may be handled to a large extent by people with limited "social capital" in the form of formal education, and thus by people with a predominantly practical orientation towards technical things, and – in line with their low level of formal education and modest social status – with little general decision making power in the social system where they are employed. These people, we may call – with a somewhat obsolete term – engine-tenders, or – with a modern term – technicians.[5] The latter function, which is a much more influential function

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[3] When most people are convinced that technology and technologists are important, this is obviously because our dependence on technology and technologists not only is obvious, but very often also is absolute. To take two examples: (1) increasingly more people need spectacles to function normally in their everyday life. Given that there is no natural selection of human beings with superior eyesight, one must expect nearly everyone in the future to depend on the use of such devices. (2) in the Netherlands, a big part of the population lives on land that was only a few decades submersed in the sea. Dutch engineers have made huge constructions that stop the sea from entering. The dykes are actually computer guided closing mechanisms that stop high waters from entering. In this way, significant parts of the Netherlands and the Dutch populations depends for their livelihoods on the constructions made by, and the maintenance provided by, professional engineers.

[4] The perspective is elaborated in Ørstavik 1996

[5] The relevant Norwegian terms would be *tekniker* and *ingeniør*.

with respect to the ability to intentionally influence the shape of things to come (and the lives of other people, now and in the future), is usually taken care of by groups with more formal education and more power. Among technologists, these are more often than not the theoretically trained technical experts; we find the terms engineers and technologists suitable for these people, and the professions they may be integrated into.[6]

But before we delve into the dynamic and evolutionary aspect of technologists' social function, in order to deal with the issue of movement of people (mobility) and flows of knowledge in networks, later, we need to look one more time at the significance of technological knowledge for technologists, as well as for society.

2.4 The knowledge base of modern societies

Although formal education also may be used to make legitimate claims for relative superiority in social and economic terms, this does not mean that knowledge and the efforts to produce and to transfer knowledge on the societal level is motivated primarily by such concerns.

Actually, one of the most significant trends shaping modern society is the increase in investments made in systematic knowledge creation. *Dependence on knowledge* is in itself nothing new. Such dependence has for obvious reasons been high even in the most primitive of societies; and – we may presume – especially in times when unfavorable conditions prevailed. It is the *size*, the *properties* (or *structure*), the *methods used in generation* and the *reduced barriers for access* to the relevant knowledge base that sets modern society apart from what has been seen earlier.

Today, almost any economically relevant activity that can be mentioned, has been made possible by the concerted effort of a large number of people, and by people dispersed over several countries and regions. And all these people's activities taken together, have only been possible because it has been feasible to access a large, distributed base of systematic knowledge, vast both in scope and in depth.

The types of knowledge that go into this knowledge base are manifold, as are the institutional structures that facilitate the sustained process of "creative destruction" which may be said to be the hallmark of modern society's ability to (in a flexible way) uphold relevant parts of the existing, and steadfast to accumulate new knowledge.[7]

We will not dive into any extended epistemological discussion at this point. We want, however, to draw attention to a few crucial facts that are of particular importance for understanding the nature of technological knowledge.

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[6] Corresponding Norwegian terms might be *Sivilingeniør, Høyskoleingeniør, Realist, Cand. Real, Cand Scient,* etc.

[7] The diversity can be expressed in many ways, and is evident also simply by the heterogeneous nature of the concept of *knowledge*. In the innovation literature, for instance, it is commonplace to distinguish between tacit and codified knowledge, and to refer to Polanyi's claim that "you can know more than you can tell". Another distinction is made between practical, common knowledge, and scientific knowledge. And of course, knowledge can be defined with respect to its area of application. In this sense, there are as many types of knowledge as there are distinct subject matters.

2.4.1 Knowledge bases are complex and heterogeneous

The most immediate form of learning and knowledge is the practical, personal learning that any individual is engaged in on a daily basis. This learning is an interactive process, knowledge evolves, and neither the learning process nor the knowledge gained is very systematic.

Although it might be tempting to look upon this as a highly individualized process, this would be wrong. Learning is personal, but also social. In real life, what is learnt and how things are understood reflects the social context that people exist in, and the interactivity of learning only in very few circumstances is between one individual only and inanimate (or non-human living) things. Much more common, and much more important, is the interactive processes of learning where the social context and the organizations in which individuals operate are important in shaping what is learnt, how things are learnt, and for what reasons things are learnt.

A lot of these fundamental learning processes result in stocks of *tacit knowledge* and practical competencies. In modern societies, these processes are not replaced, but complemented by institutionalised efforts to build systematic, explicit and accessible knowledge bases. Such systematic efforts happen in organizations, as rules and procedures are recorded, and systems implemented that can secure sustained and mutually reinforcing interplay between “theory” and “practice”. But beyond this, modern societies maintain and expand more or less generally available knowledge bases, and secure the vital “theory” and “practice” interplay, through a comprehensive system of institutions for education and science.

Contrary to what has been assumed in economic theory,[8] knowledge (and technological knowledge) is not universally accessible. While individual tacit knowledge is highly personal, significant elements of modern societies’ knowledge bases have been developed inside, is stored in, and is available for individuals only by being members of the organization and taking part in this organizations activities (for instance by learning the routines and the norms that have been institutionalised and gradually refined in the socio-technical system which this organization is made up of). While knowledge and learning is never purely theoretical, nor perfectly systematic and abstract, the high-level academic institutions deal with knowledge that is closer to this extreme than most other institutions. Academic institutions have a culture that is marked more by values of universalism, openness and disinterestedness, than many other institutions.[9] The systematic structure, the codified nature, and the open academic culture contribute to making scientific knowledge more accessible than most other types of knowledge. Of course, other aspects of the scientific knowledge base can be seen as de-facto barriers to access. Most importantly, most scientific discourses utilize highly specialized language, which may be understandable only for those that have become part of the specific scientific “tribe” involved, through their education.

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8 Arrow 1962.

9 Barber and Hirsch 1962. We are aware of recent criticism of the traditional view of the values of science, and we agree that the case for a value-free and disinterested science is often overstated. See also Latour and Woolgar 1979, Latour 1987 and Fleck 1935.

Technological knowledge is obviously only a subset of available knowledge. It is not only theoretical and abstract, but it is marked by being a combination of practical and theoretical, systematized and codified knowledge. In this sense, technological knowledge bases are heterogeneous, much in the same way as the overall knowledge base of modern societies is heterogeneous. It is important to note, however, that technological knowledge always contains elements of practical knowledge developed "on the shop floor" as well as elements that are scientific in nature.

2.4.2 Knowledge is maintained by diverse social groups

There are many and diverse fields of knowledge, and there are many and diverse social systems that uphold and extend these knowledge fields. If we look at this "horizontally", we can distinguish different types of technological knowledge as they relate to – and are formed around – different types of activity. In some cases, the experiences of people doing similar things may lead to the formation of networks, and even of institutionalised communities around the activity. The definition of a technology and the definition of a community then become intertwined and inseparable. In this way, specific work (and specific technology) may lay the ground for the formulation of social groups and even distinct subcultures in society.

2.4.3 Professionalisation

Some of these groups take a more permanent form, and use means such as privileges awarded by a ruler (to use an old term), or by a governance system (to use a more fashionable term), to establish themselves as an interest group, and as a profession. These groups can form lasting and influential elements in the basic structure of society. One of their most interesting properties is that they may have managed to establish a legitimate monopoly as administrators of a specific area of knowledge. The group governs both the development of the knowledge base, and the applications of this knowledge in society. The social structure of these communities, as well as the structure of the body of knowledge that they administer and control, may have a clear cut hierarchical form, and the certification systems and status distributions strictly governed.

This in an interesting way mirrors the internal structure of scientific institutions and scientific knowledge. Also in science, knowledge is structured, systematic and development of new knowledge regulated by specific norms. It is not surprising, then, that there actually is a significant overlap between the institution of science and the professions. We will not here pursue an analysis of this relationship, but wish to point out that there is mutual dependency and an interesting interplay as the professions and scientific institutions and scientific knowledge develop.[10]

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[10] One interesting parallel is found in the built-in inclination to globalisation that marks healthy science as well as sound professions. It is not hard to find localized scientific groups with what is in the local context considered a legitimate claim to authority in a certain knowledge field. The reach may be too limited and too much separated from the central scientific discourses to be considered integrated into the actual progress of science. An illustrating example might be a group of physicists in the physics department of a regional university. These academics may dominate what is taught at their own university, but their say in shaping physics in a wider context may be nil. Similarly, localized and bounded professions – or profession-like social groupings – may dominate the development of knowledge and its applications, and the claim to represent "state of the art" may be

2.5 Innovation as building of heterogeneous networks

It has been observed that the technical professions, and the engineers and technologists inside them, like to think of themselves as *master builders of society*.[11] They are eager to show that their role is a creative one. Development and innovation is the key issue, not mere maintenance of what is already an established reality.

> *[the technologists] are at the drawing boards and behind the laboratory benches; they apply for patents, model the prototype, and test in the pilot plant; they show the newly born artefact to the press and, if lucky, they figure prominently in the glossy photographs of stories about heroic inventors.* [12]

While the Dutch engineer and social analyst Wiebe Bijker, who has written this paragraph, goes on to refute the well known continuation of this story, where the linear model of innovation processes are laid out in its bare form, the descriptions of everyday work of technologists still rings true. Others tell similar stories. In Kidder's "The soul of a new machine", as in Traweek's "Lifetimes and beamtimes"[13] vibrant accounts shows us how intimate the relationship can be between technologists and the devices and processes that they construct. Such authors show us how technical experts by amassing practical experience as well as theoretical knowledge (familiarity with, understanding of, and ability to criticize and further develop symbolic reconstructions of the internal and external functioning of artefacts and systems), develop:

1. empathy with the inanimate elements of a mechanism or a system,
2. knowledge about the opportunities (or the "degrees of freedom") that the properties of technical devices give to create predictable and reliable mechanisms and systems,
3. the ability to understand the *meaning* that artefacts have for diverse *relevant social groups*, and
4. an ability to handle the politics and the negotiations that are an integral part of making the artefacts work in the larger socio-technical system in which they need to be assimilated in order to be sustained.

Technologists build things, construct mechanisms and develop systems, and in order to accomplish this, they have to have deep knowledge of the relevant scientific and technological knowledge bases that they need to build on. But in doing their constructive efforts, they cannot consider technicalities of materials and tools only. They have to develop functioning wholes that have a place also in the minds of relevant people, and in the functioning of the social and technical reality (socio-

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accepted in this local setting. However, the professional group will always be susceptible to criticism from informed observers with knowledge about similar knowledge and applications in other places. There is a tacit assumption that the group that controls a field of knowledge and its application is up to date with respect to global developments in the area.

[11] See Nagell 1974. See also Ørstavik 1996.

[12] Bijker and Law 1992: 75.

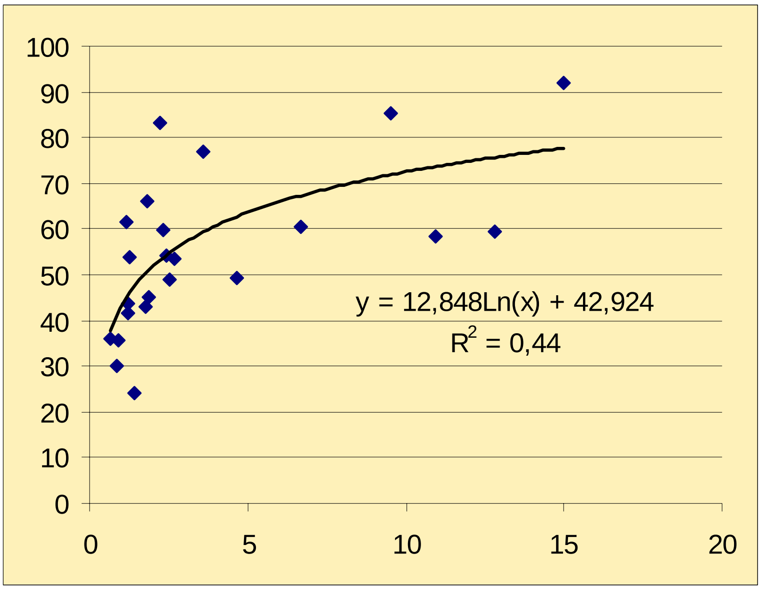
[13] Kidder 1981, Traweek 1988.

technical system, or society) that forms the habitat in which the new artefact of process must survive, or perish.[14]

In order to accomplish their task, the creative technologists have to build not only machines, but also socio-technical systems. In order to innovate, they have not only to build working mechanisms, devices or systems, but they have to make sure that the new technical devices are assimilated in vigorous assemblies of artefacts and people. They have to care for the shaping of minds and mindsets as much as for the construction of inanimate things. They have to change a piece of society in order for the new that they create to become sustained and sustainable elements in an evolving social (and also technical) system.

Innovating technologists must, in other words, create sustainable *heterogeneous networks*. The social analyst's interest for social networks as well as the innovation analyst's interest for collaboration between innovating firms and other institutions are concerns with elements or aspects of this broader effort of constructing "heterogeneous networks".[15] An interesting graph demonstrates clearly how data reflect this co-variance between the presence of technologists in firms, and the firm's tendency to collaborate with others in connection with innovation. Technically, the figure shows the percentage of firms that engage in innovation collaboration as a function of the engineer density of the firms across industries in Norway.[16]

Figure 2.1: Innovating technologists as network builders



Source: Register data and Community innovation survey data, SSB/STEP.

[14] Bijker, Hughes and Pinch 1989, Bijker and Law 1992, Latour 1987, Rosenberg and Kline 1986, Sørensen and Levold 1988, Van de Ven 1999.

[15] The literature on networks has been surveyed in Ørstavik 2001.

[16] Relationship between average propensity to participate in innovation collaboration for firms in an industry according to CIS data, and average share of technologists of total employment in firms, by industry according to Norwegian register data. Thor Egil Braadland (STEP) has developed the illustration.

2.6 The dual functions of networks

To sum up the key points of the argument so far: Technological knowledge, and technologists, are very important in modern societies, and they are important for two reasons: First, they are instrumental in day to day operation of the technical dimension of our societies, and second, they are crucial in further developing this domain. The knowledge that is pertinent for the dual mission of technologists to be accomplished is a complex mass of diverse, but related knowledge fields, and the social structures maintaining the "ecology" of knowledge bodies is in itself manifold and multifaceted.

It is in innovation that the highest potential of technologists is realized. When taking part in innovation, technologists not only maintain what already is around us, they lay down basic premises for future development of society. They influence in a direct and significant manner the way people live and the way they work.

Innovation is most aptly described as an interactive, goal-oriented but basically unpredictable process of creation of "heterogeneous networks". But networks are not only the result of innovation. As a resource, networks are vital for the effective functioning of innovation processes.[17] When engaged in innovation, technologists need to exploit their own personal expertise and knowledge, but no less, they need to be able to benefit from the social context in which they are integrated. This might be a company organization, a university or some other institutions, or it might be a professional community, in which the technologists are members on the basis of their status in terms of area of expertise, work position, formal education, or other certifiable competences which makes them into peers, and as such also valuable potential resources for other technologists working in the same area.

Thus, networks are both a means and an end in innovation. Networks give access to resources, and are an effective means for channelling knowledge while at the same time protecting interests of the people involved. The social structures of professional networks and professions are an effective warranty against exploitation, it establishes a fundament for trust, and thus facilitates communication and knowledge transfer.

Technological competence is embodied in products and processes, it is recorded in more or less structured and codified knowledge bases, and is embodied in organisational routines and regulations. However, a most significant part of technological competence is the competence embodied in living human beings, in the technologists themselves, as well as in other people who are part of the social groups that are relevant for an innovation effort.

In the process of innovation, which fundamentally is a negotiation process where both inanimate and animate objects have to be lured into reliable collaboration, it is obvious that it is of utmost importance for the technologists to manage to utilize state of the art scientific and technological knowledge. This is essential because it is this kind of knowledge that is needed to make technical systems that would appear "impossible" from a common sense point of view. Advanced knowledge reveals the degrees of freedom available to make technical designs work, irrespectively of what has been seen for, and what is proven as possible in what has already been produced.

However, there are much broader needs than the “technical” ones. A lot of knowledge is needed to make the social elements of innovation puzzles fall into place. The needs of users, the inclinations of regulators, the values found in the culture that dominates in the context where the innovation is to be assimilated; all are crucial factors. Therefore, networks are crucial as communication channels also outside the circles of technologists themselves.

2.7 The significance of technologist mobility

In a stable production system with perfect organization, no mobility would in principle be necessary, beyond the influx of skilled technologists into positions left vacant by those leaving their occupation because of sickness, age or death. But stability and perfection is not the right words to describe the state of affairs in modern economies. Economic activity involves incessant change. Products, production methods, organizations and user needs change all the time. Competitive pressures force people and firms to change their ways. Business development is an ongoing struggle. The formal education received before starting a work career is not adequate training for performing any real life job. It is a prerequisite, as it provides both competence and a certification of a certain kind, but learning will be an on-the-job activity throughout the career. This is why firms (and other organisations) also need to recruit people from other sources than educational institutions, in order to secure adequate influx of technological competence.

2.7.1 Mobility facilitates knowledge transfer and communication

Knowledge is not free, and not universally available. Solutions to changing technical problems and new ideas about technical opportunities are important factors in the dynamics of modern economies. The people with new ideas may or may not have good knowledge of the technical issues involved. New technical ideas and opportunities may spring from a plethora of non-technical considerations. In this sense, the sources of invention are truly diverse. But new ideas and opportunities may certainly also be triggered by technical issues, and in people with the most intimate knowledge of the technologies and artefacts concerned. Whatever the origins, changes in products and processes can usually only be realized when technically competent people are involved in the process.

The crucial resource issue is access to knowledge. As futile as the idea that knowledge is universally available and free, is the idea that communication is unlimited and perfect. Insurmountable barriers to communication, between people and between organisations, very often hinder access to relevant knowledge. “Cultural distance” and “Not invented here” attitudes are central to any appreciation of why innovation is a demanding challenge; even when technical problems can be solved easily.

Mobility is a key to resolving such issues. Mobility means at least two important things: It means first, that the knowledge possessed by the individual is transferred to a new context, and this means there is a potential for mutual learning which can be instrumental both for generating innovative ideas as well as for finding solutions to existing problems. Second, mobility represents a potential for bridging gaps between people and organisations that have a lot to learn from each other, but which for various reasons do not communicate very well. Communication and trust is a means both for effective search and efficient knowledge transfer.

What is in this context a quite special kind of mobility is the flow of new graduates from higher education institutions to industry and the public sector. Young people fresh from university bring with them updated scientific and technological knowledge, and help securing that a high level of competence in the receiving institutions can be sustained. As will be shown later, this is the kind of mobility that clearly is the most important one in quantitative terms.

2.7.2 Mobility facilitates the constructive negotiations of innovation

We have seen how mobility of technologists may help to make resources available that can be very important for innovation. In addition to this, mobility can facilitate the negotiations of meanings and interests that are at the very core of innovation processes. Communication and trust form a fundamental premise for effective negotiation and influence with respect to relevant others.

This is why it is an advantage for innovative organisations to encourage the movement of employees out to other organisations that are among the relevant others respect to innovation. Collaboration with advanced customers, suppliers or regulatory bodies is in itself important in order to facilitate communication and understanding. The transfer of people, temporarily or permanently, may both contribute to the positive effects of collaboration, and be a result of this collaboration. Some innovative organisations see the potential in this kind of personnel transfer, and encourage it in various ways.

2.7.3 Mobility facilitates entrepreneurship

As a final point, we wish to mention the fact that the move of salaried employees or of graduates into business start-ups represents a particular kind of mobility with particular relevance for innovation. In the meeting between old and new which takes place when people move into existing organisations, most of the time, the freshness of new ideas is rather quickly worn down by the strength of established norms and routines. More often than not, young people, or new people, with different ideas learn to play the existing games, and adopt existing views.

However, when such people take new initiatives, establish new firms and activities, the potential for innovation is great, in the sense that the new ideas are not killed by conservatism from any organisational establishment. Obviously, start-ups face several other big challenges, and it is no easy task to succeed. The significance of this kind of mobility is a function among other things of survival rates. This is a theme well worth further research.

2.8 Summing up

We wish to conclude these introductory notes on how we should theoretically account for technologists and their significance for innovation, with pointing out how complex the relationship is between networking and mobility. The crucial factor for innovation is access to relevant knowledge, and the ability to transfer knowledge to relevant others. Networking and mobility are in some ways complementary: If there are good networks, mobility may be quite unimportant. If there are no networks, mobility may be essential. It is then quite paradoxical that networks and mobility may seem to depend on each other: It seems that you cannot get one without the other.

What this may indicate is that networking and mobility are but aspects of the same phenomenon, namely social integration. That would mean that innovation depends strongly on social integration. This contradicts a common perception of innovation and technological change, which is that these factors are disintegrating mechanisms in any societies: An economic need, but a social evil. An alternative view to this pessimistic one could then be offered: Maybe it is so that development and change is an integral part of any healthy organism, whether this organism is a human being, an organisation or a society in its entirety.

Chapter 3. Mobility and knowledge diffusion

3.1 Introduction

The rationale for mobility research is of course that mobility of humans is obviously one of the important mechanisms of knowledge transfer. There are of course many other mechanisms, but since Medieval times highly skilled persons have been moving in order to learn – and been called upon to educate others by working together with them.

The basic problem of mobility research is that it is relatively easy – especially with register data – to quantify the mobility. The real problem is to measure the contribution of mobility. This is very parallel to the question of the impact of R&D – it is easier to measure the inputs – routinely defined as the costs – than to measure the output/results and relate them to the input(s).

Another aspect of this is of course the distinction between tacit and codified knowledge. We know that it is important, but it is hard to find reliable and generally useful indicators for it[18]. As a consequence this report will explore mobility patterns, being well aware that mobility is actually just the result of various different processes:

- closures and down-sizing
- people fleeing from bad management
- people searching for better wages and benefits
- people seeking new intellectual challenges
- chain effects: spouse changing job and residence and thereby forcing the person to change job and residence.

In various ways and to a varying degree we can try to single out such processes, but even if a job change is caused by any of the various processes above there might be a significant and positive transfer of knowledge for the receiving institution.

[18] A more general discussion of the relation between codified and tacit knowledge is found in the paper on researcher mobility.

Chapter 4. The Canberra Manual

The Canberra Manual, - published in 1995 - is the newest of the "Frascati" family of innovation related manuals. The manual itself is an indicator of the growing importance of human resources of science and technology (HRST) in policy formulation. While it outlines in brief the various policy areas where HRST is important, the main purpose of the manual is to discuss the definition of HRST and the classifications and standards to be used to make the definitions operational. There is also a short overview of existing databases: however, the manual does not explicitly discuss data collecting-, reliability and validation issues. We shall, however, see that the classifications and standards used reflect the data available.

4.1 The policy issues

The policy issues are of course the motivation for the definition of concepts and the information collected. The Canberra Manual formulates its own purpose in this way:

> "The combination of science and technology (S&T) and human resources (H&R) is seen as a key ingredient of competitiveness and economic development and also as a means of safeguarding and enhancing our environment over the coming decades. New technologies are being developed and applied, very quickly in many cases. An increasingly skilled and effective workforce will be required if countries are to negotiate the rapid change and new challenges that are emerging in S&T."

The policy issues fall into various categories:

- General demographic issues (ageing, demographic downturn)
- Structural changes and their repercussion on the labour market (e.g., decline of defence industries may lead to a surplus of specialists with what was once scarce S&T skills)
- The internationalisation of the labour market for HRST
- Brain drain, brain gain in different contexts (international, regional and sectoral)
- Issues relating to education and training (planning supply, the actual use of acquired education and training)

There are of course many other possible research areas not mentioned in the Canberra Manual, which reflects the fact that most countries have rather limited data sources that can be used to answer the many policy questions related to human resources in the economy.

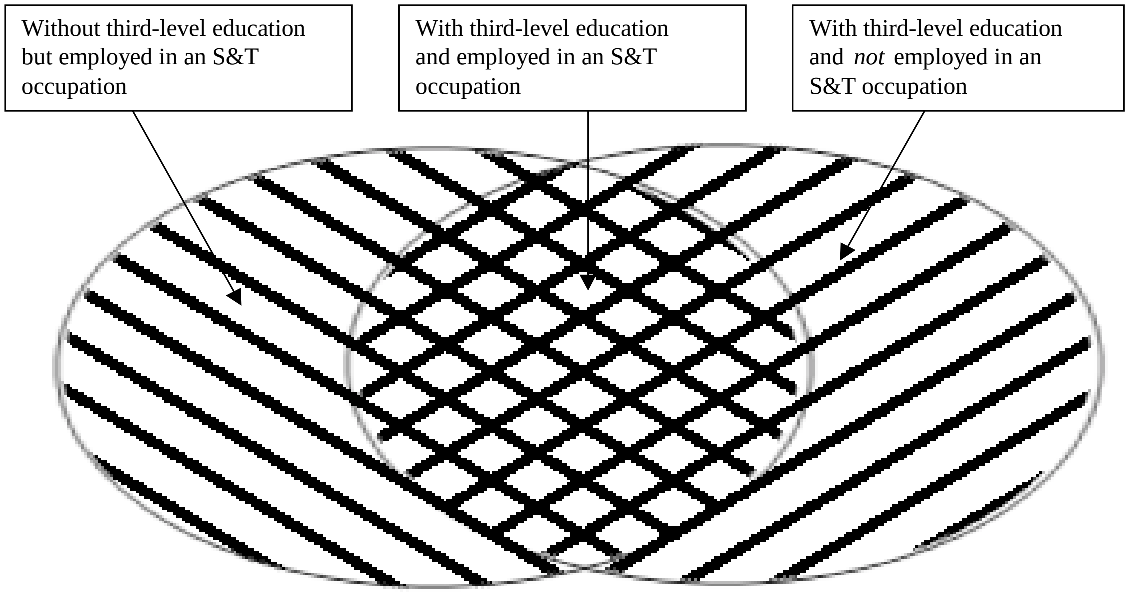
- The interaction between industry and the public research system
- Inter-firm flows of highly skilled human resources
- Gender and mobility
- Job creation and destruction in a macro economic employment perspective
- Job creation as entrepreneurship, like spin-offs from firms and academic institutions
- What happens to HRST when hi-tech, high-risk firms are closed down or taken over?
- The HRST-flows between public sector and private sector
- Studying the mobility patterns of for instance IT-specialists, and other narrowly defined educational or occupational groups

The list could easily have been much longer. Rosengren (1998) asked national experts on S&T indicators to prioritise a limited set of research topics, to see if there was any convergence. Rosengren, however, emphasise: one should be very aware of rankings based on the opinion of such experts, in most cases one expert per country. What emerges from Rosengren's study is that there is a rather common set of policy issues, but that the precise formulation and the priority is determined by the political agenda in each country. The political agenda in its turn being dependent on the business cycle, planning of major reforms of the educational system etc.

4.2 The population

The population of HRST is defined using two established classifications simultaneously: the International Standard Classification of Education (ISCED) and the International Standard Classification of Occupations (ISCO). The HRST encompasses those who either have a formal education in the field of HRST or have a job where such an education is normally needed. The defined territory is meant to delimit the group of persons that is central for the development and diffusion of technology in a national innovation system (NIS)-perspective. The manual wants to show both the potential resources - being qualified but not working, or working in occupations where their education is not relevant - and the actual resources, i.e. those working and using their education and experience.

Figure 4.1 The definition of HRST by means of occupation and education



There are of course a lot of the HRST persons who are doing more routine work and others more directly involved in innovation and diffusion, however, given the data available this is very hard to measure.

Manuals such as the Canberra Manual and the other manuals in the "Frascati" familiy are of course not meant to be canonical texts. They are under constant development as researches get more experience with using the manuals and trying to make the definitions of the manuals operative. The manuals explicitly state that the definitions worked out so far need to be tested by being utilised in various research and policy contexts and then changed or refined.

4.3 The Canberra concept of HRST and the Norwegian statistical system

The major problem with trying to use the definition of HRST in the Canberra manual is the lack of occupational codes in the Norwegian statistical system. Registration of occupational characteristics are not totally absent, there is occupational information in the Labour Force Survey (LFS), there is occupational information in the databases of the Labour Marked Authorities, but it is not a classification that one can get for the whole active population, or any large subgroup of the active population. This is of course regrettable because it makes it impossible to use the Canberra definition of HRST with the otherwise very rich Norwegian register data.

This said, there is a set of well-known problems with occupational classification in general. The authors of this paper are of the opinion that there are problems with the International Standards for Classification of Occupations (ISCO). It might be useful to make a brief discussion of the ISCO standard at this point, before we go on to discuss in much greater depth the classification of education.

4.4 The problems of Occupation statistics

The classification of occupations is much more difficult than educational classification due to the greater dimensionality of occupation, and the varying prestige attached to different occupations in different cultures. The dimensions of "occupation" are at the very least:

- the structure of decision power in the workplace
- the type of work (routinized, creative etc.)
- the field of work (classified according to materials used, techniques, markets served, education/certification required)
- institutional setting (public, private etc.)
- social status of the occupation

The best way to describe such a multi-dimensional area is to have a combined index with one or more numbers expressing the ordinal scale in each dimension. The International Standards for Classification of Education (ISCED) typically has a first digit for "level" and a second digit for "field of study". Each of these dimensions can be regarded as homogenous, as measurable along one line/dimension.

For historical reasons the International Standards for Classification of Occupations (ISCO) has not been organised with homogenous dimensions. This leads to a situation where different dimensions are measured on the same ordinal scale (digit level). Our impression is that one major source of the problems with the ISCO classification is this mixing of dimensions. The first digit level in ISCO is defined along several dimensions at once:

- in terms of the hierarchy in the workplace (managers versus subordinates)
- in terms of ISCED level codes (highly educated, skilled and unskilled)
- in terms of field of work (technical, administrative)
- in terms of the institutional context (the armed forces being a one-digit group)

This means that making the Canberra Manual operative is not a straightforward matter. It is not easy to single out those working with S&T. Related to the armed forces one has to do a time-consuming job of selecting sub-groups and combining them with the similar other subgroups. The end result will be a non-standard selection. The technicians in the armed forces are of course not the most important problem.

One of the major problems is separating administrative managers from highly skilled professionals. Trying to implement the Canberra definition has sometimes led to a situation where one just gets too many HRST people. The most common problem is the classification of managers, most of whom are not doing much technical or scientifically related work, rather having a clear-cut management/administrative role. Managers, however, often have an education on a level of such kind that make the occupational statistics register them in such a way that they will be covered by the rather broad definition of HRST of the Canberra Manual (cf Stimpson (2000).

But even if the ISCO had been organised as a series of numbers representing rather homogenous dimensions like position in the firm hierarchy, kind of work, field of work etc., there are still major problems in the way data is collected. The information on occupation is very often stemming from the persons themselves. Unfortunately we do not have – even on a national basis – a common way of describing occupations, what the actual work consists of. This will then require a further judgement by those responsible for transforming the information into the ISCO-codes. In other cases there are experts judging from indirect evidence. In both cases experience shows that there is no consensus for interpreting this kind information.

Various recoding exercises, e.g. letting two different groups transform the same set of job descriptions into ISCO codes have been carried out to check both different kinds of coders and different types of coding. These exercises have shown that there are differences between persons with identical training as well as between trained coders (i.e. staff in the national statistical offices) and various groups of experts. There is an 80-90 percent agreement at the first digit level, going down to 70-85 on the second digit level[19]. There is no a priori reason to believe that the "expert" coding is more consistent than other groups of coders. Some even claim that there is more disagreement about coding among "experts" than trained coders. How much such problems would be corrected by having homogenous dimensions on the various digit levels is hard to predict, but it would at least have made the classification easier to use.

As mentioned above the occupational classification has not been part of the Norwegian statistical system up until now. From year 2000, as a consequence of the close cooperation on an European level, there will be occupational codes in the future but only as part of the Labour Force Surveys (LFS). Since both the LFS and the register data use the same person ID-number one will be able to do some analysis of occupation using both data sources. Despite the deficiencies of the ISCO as a standard this will add important and significant information about the stocks and flows of knowledge and their use when the system is up and running.

[19] See Peter Elias, ”Occupational classification (ISCO-88): Concepts, method, reliability, validity and cross-national comparability”, Labour marked and social policy – Occasional papers No 20, OECD, available on OLIS

Chapter 5. The Classification of Norwegian education

Educations in Norway are classified in a national classification system using a 6-digit code. There exists a mapping of these codes into the International Standard Classification of Education, ISCED, both the old standard ISCED-76 and the new standard ISCED-97. The mapping of the Norwegian standard into ISCED-76 is relatively straightforward. There is also a mapping of codes from the Norwegian Classification of Education (NUS) to the new ISCED-97, but since the ISCED-97 has a more complex structure, this mapping is not as simple. In our opinion it is discussable whether the new ISCED-97 is really a progress over the ISCED-76 in making educations comparable for statistical and analytical purposes. The authors' view on this matter is that it is not as obvious as it should be when one makes a major change in an international standard as important for the study of competence and of human resources as the educational classification is.

In this report I will use the NUS and that is not only a question of getting more detail or a question of convenience[20]. It is basically a question of how you think education should be classified, which in turn is based on a view of what aspects of education are the more essential. This is not the place for a fundamental discussion of this, but since highest achieved education is used as *the* proxy for competence throughout this study, it is necessary to take a closer look.

5.1 The length, intensity and quality of education

When classifying education one of the first obstacles is how to treat the question of intensity. All the educational classifications are based on the principle that the intensity of education is best measured by using just the length of the education as an indicator of quantity and quality of education. Ideally one could define a normal intensity, and then weigh different educations according to their intensity, based on various sources of data. One could measure the number of hours spent on lectures, studying etc.. Besides the fact that it would be costly to get the data needed for constructing such weights, it is an open question whether the results would be really useful. First because the individual effort varies so much - there are hardworking and lazy students in all fields. Secondly the forms and consequently the intensity of education vary a lot, according to subject matter and the traditions of the various educational institutions.

Likewise one might have weighted the different fields of study according to their intensity/quality. Hypothetically one could choose a norm, the humanities and regard one year of theoretical physics as counting for one and a half year of history. But one

[20] In other comparative projects that are thematically related to this one Norwegian data are published using both the ISCED-76 and the new ISCED-97

could argue against this saying that in every field of science the education is as advanced as the average abilities of the students– and these abilities for learning are on average equal so that there are no selection bias between the various fields of study when it comes to talent, IQ or what ever one chooses to call the human potential for learning. That is to say the most brilliant social scientist is as capable as the most brilliant mathematician. They did choose their field of study according to personal preferences and not as a second best because of lack of intellectual capability.

This may sound rather philosophical but the practical consequence is that one uses the length, i.e. the number of years of education to group the educations in different levels. That means in practice that in a lot of international comparative statistics and numerous research reports, very different educations like two years of theoretical physics at university level will count equal with two years of training as a nurse since both of them are the 13^{th} and 14^{th} year of education. Depending on the problem to be analysed this might be more or less appropriate. In a macro-economic growth perspective this might not be very controversial since the economy needs both nurses and engineers, but when looking at market shares in high-tech products, patenting etc. then using the total stock of highly educated might lead to less significant results than using the stock of HRST or more detailed breakdowns of education.

5.1.1 The fields of study

In the Norwegian educational classification system the second digit is the field of study. Since the classification is numeric and hierarchical there is a maximum of ten possible groups at the top level. Again choices have to be made on how to group them. In the Norwegian classification we find the following top-level fields of study:

Table 5.1: Top-level fields of study, Norwegian classification of education

	Norwegian	**ISED-76**	**Field of study**
1	720000	70000	HUMANIORA OG ESTETIKK (Humanities and estethics)
2	730000	71400	UNDERVISNING (Education)
3	740000	70000	ADMINISTRASJON OG ØKONOMI, SAMFUNNSVITENSKAP OG JUS (Administration, economics, social sciences and law)
4	**750000**	**70000**	**NATURVITENSKAP OG TEKNIKK (Natural sciences and technology)**
5	760000	78900	SAMFERDSEL (Transport)
6	770000	75000	HELSEVERN (Health care)
7	780000	76200	JORDBRUK, SKOGBRUK OG FISKE (Agriculture, forestry and fishing)
8	790000	70000	TJENESTEYTING OG FORSVAR (Services and defense)

One could easily think of other ways to group these fields of study. Today, probably services would not be grouped together with Defence. One might discuss whether the content of the Agriculture, Forestry and Fishing education has become so “bookish”, that is theoretical, that it should have been a sub field of natural sciences[21]. There are also other aspects to be taken into consideration when grouping educations like this. One might from the view of substance or content regard Transport as a top-level

[21] One indication of this is that there are more persons with long educations, 4-6 years at university level than short 1-3 at university level.

education, but there are very few persons that actually have that education at a university level. Only 29 persons have higher, university level education in Transport, so it might be considered luxurious to have this as a separate top-level category. It disappears completely in graphs and tables when shown together with the other major groups at the highest levels of education. On the lower levels there are more people in Transport, primarily related to maritime navigation. But again one could ask if not educations related to tourism should be classified under services, and whether ship-engine educations should be classified together with non-maritime engine related educations.

5.2 Norwegian Classification of Education (NUS) and ISCED-76

There is no one-to-one correspondence of the top-level categories of NUS and ISCED-76. The obvious reason for this is that ISCED-76 does not have a decadic hierarchical structure that is, using one digit per level. The field of study in ISCED-76 is divided into 16 fields.

Table 5.2: Field of study in ISCED -76

Field of study	**Code**
Education science and teacher training	x14
Fine and applied arts	x18
Humanities	x22
Religion and theology	x26
Social and behavioural sciences	x30
Business administration	x34
Law and jurisprudence	x38
Natural science	x42
Mathematics and computer science	x46
Medical science	x50
Engineering	x54
Architecture and town-planning	x58
Agriculture, forestry and fishery	x62
Home economics (domestic science)	x66
Mass communication and documentation	x84
Other programmes leading to a univ. degree	x89

Beside the fact that ISCED-76 uses two digits to allow more top-level categories there are some marked differences in relation to the HRST fields; Firstly, engineering is singled out as a separate category and if one looks at the sub-fields it includes agricultural and forestry engineering. Secondly, the category Agriculture, forestry and fishery include “Food science and technology” that one might feel inclined to classify under “Natural sciences”. The category Engineering in ISCED-76 might be considered as a deviation from the principle that one should classify educations according to their subject matter, and not according to their degree of “appliedness”. One might also wonder why mathematics and physics are separated, both being fairly theoretical.

5.2.1 The 3rd digit sub fields of Science and Technology

In the NUS there is a change in the structure of sub fields at university level and below. For all S&T-educations at university level 5, 6, 7 and 8 there is the following set of sub fields:

Table 5.3: All S&T university level sub fields (5, 6, 7 and 8)

NUS	ISCED-76	
751000	74600	MATEMATISKE FAG (Mathematical subjects)
752000	74200	FYSISKE OG KJEMISKE FAG (Physics and Chemistry)
753000	74200	GEOGRAFISKE OG GEOLOGISKE FAG (Geographical and Geological)
754000	74202	BIOLOGISKE FAG (Biological)
755000	75442	MASKINTEKNISKE FAG (Engine technical)
756000	75422	ELEKTROTEKNISKE OG DATATEKNISKE FAG (Electro technical and Computer)
757000	75412	KJEMITEKNISKE FAG (Chemistry)
758000	75400	BYGGE- OG ANLEGGSTEKNISKE FAG (Construction)
759000	70000	NATURVITENSKAPELIGE OG TEKNISKE FAG ELLERS (Natural science fields not elsewhere classified)

As a rule each of these categories get divided into three to five “obvious” sub fields. Mathematics is divided into actuarial, statistics, mechanics and general mathematics. Biology is divided into botanic, zoology etc. Sometimes these sub fields are more oriented towards professions like actuarial mathematics. For the engineers this applied aspect is naturally more pronounced than for the university studies.

There is one major exception to this hierarchical system and that is the IT-educations that are classified either under digit 1 – Mathematics or where they “really” belong – under digit 6. This probably reflects that IT-educations were started as a part of the mathematics departments’ programmes of education before being institutionalised.

5.2.2 The NUS and the ISCED-97 definition of Science and Technology

The NUS and the “new” ISCED-97 do not structure the fields of education the same way. Since both classification schemes has a decadic-hierarchical structure there are differences in the first digit structure – the main fields of study. There are also differences in where particular, rather homogenous fields are placed. The most important part of the ISCED-97 structure is reproduced below, for a full list see the appendixes.

Table 5.4: The Science, Mathematic and Engineering related fields of study

4	**Science, Mathematics and Computing**	**5**	**Engineering, Manufacturing and Construction**
42	Life science	52	Engineering and engineering trades
421	Biology and biochemistry	520	Engineering and engineering trades (broad programmes)
422	Environmental science	521	Mechanics and metal work
44	Physical science	522	Electricity and energy
441	Physics	523	Electronics and automation
442	Chemistry	524	Chemical and process
443	Earth science	525	Motor vehicles, ships and aircraft
46	Mathematics and statistics	54	Manufacturing and processing
461	Mathematics	540	Manufacturing and processing (broad programmes)
462	Statistics	541	Food processing
48	Computing	542	Textiles, clothes, footwear, leather
481	Computer science	543	Materials (wood, paper, plastic, glass)
482	Computer use	544	Mining and extraction
		58	Architecture and building
		581	Architecture and town planning
		582	Building and civil engineering

On a one-digit level there is a main division between Science and the more applied educational fields in the ISCED –97 structure. However, the combination of 4 and 5 cover most of what we find at the one digit level under the heading “Natural Sciences and Technology” in the Norwegian NUS. There are some notable exceptions: some environmental educations that are NUS one-digit field 5 is under 8 “services” in ISCED-97. When comparing the ISCED-76 with the ISCED-97 one might ask what is gained by separating engineering educations from manufacturing. Very traditional economic sectors like Mining have strong engineering traditions and could very well be a separate category under engineering.

5.3 Educational classifications – summing up

The purpose of discussing some parts the Norwegian NUS and the old and new international classification systems is mainly to exemplify that there is no naturally given way of classifying education, not even when it comes to science and technology related fields. However, the three classification systems are of course not that different. The main differences and those that are most difficult to handle is mainly caused by not trying to classify according to one criterion at the time. Ideally one should classify the fields of study according to their subject, or use a broader concept: according to their “knowledge base”. Each field of study could then be seen as a node in a network, i.e. being a particular combination of fields of study, specific methods used etc. In this respect the NUS is at least as coherent as the two international classifications. The international classifications seem to offer no special advantages in studying the HRST stocks and flows in Norway on a general conceptual level.

One might argue that for the sake of international comparability the international classifications should have been chosen, but the experience of the authors from work in Nordic and OECD contexts is that the use of international classifications is only the starting point. Since most countries translates their national classification into ISCED the translations have to be checked to ensure that one compares different sorts of apples and not apples and oranges. This is especially the case with ISCED-97 that deviates the most from the principle of “homogenous dimensions”. The ISCED-97 is also potentially the most dangerous because it makes it very convenient to use some categories like “5a” in comparative work. But “5a” is in fact then divided into short, medium, long and very long educations – that are radically different in their level. Using this “extra” information on the actual length of the education is computationally complicated and thus too seldom used in practice. This is clearly an example where the first digit should have been used to make the actual differences explicit.

Chapter 6. The stocks of HRST in Norway

In this chapter we are first going to give a very brief overview of the spectacular rise in the general education level in Norway before going into a much more detailed analysis of the HRST, a more explorative section. One major reason for not using rigorously formulated models in this analysis is that the field of mobility studies is very new and that there is a need for "pre-model" investigation. "Pre-model" investigation does not mean "measurement without model", because there are several underlying questions, some are already mentioned in relation to the Canberra manual, other examples are:

Are the HRST where we would expect them to be most productive?

We will here be using "conventional wisdom" looking for engineers in manufacturing and placing a question mark if there are "too many" in public administration and services. Those using more rigorous models are often looking only at manufacturing sectors, since productivity is even harder to define in services and public sector administration, not to speak of getting the appropriate data.

Are HRST mobility rates "normal" compared to other educational groups?

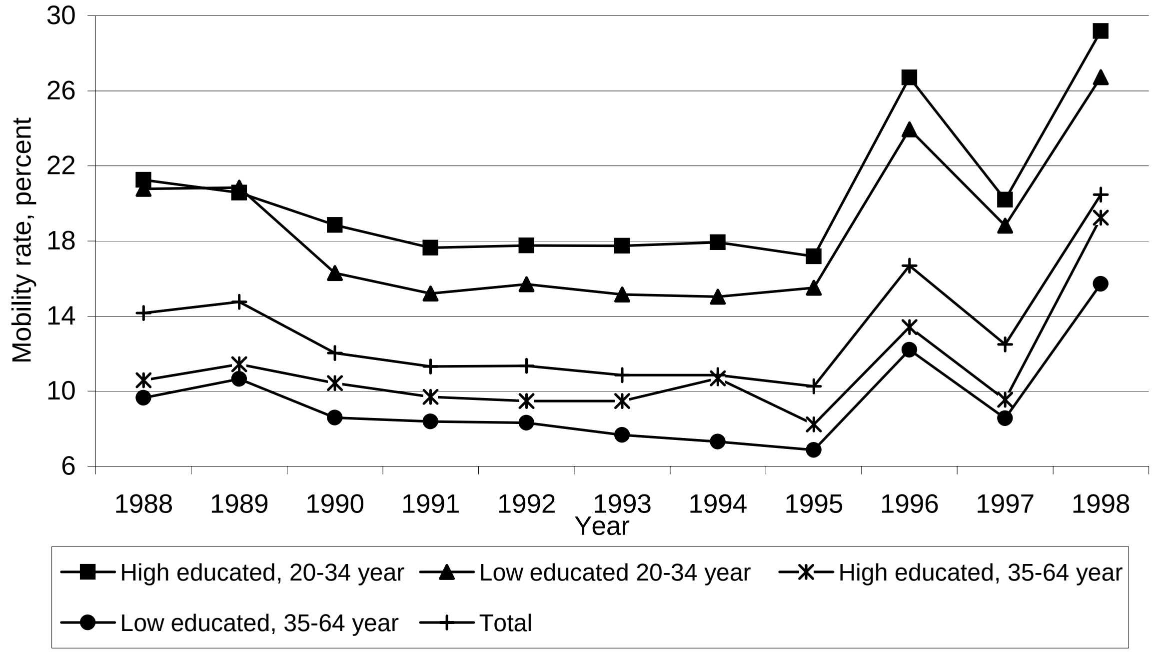
One of the a priory things we know about mobility is that it is an "optimal" phenomenon, that is, one should avoid the extremes:No mobility meaning stagnation, very high being an obstacle for accumulation of knowledge, team-work, long term product development etc.

Mobility rates and supply/demand in labor segments

One of the stylised facts[22] from mobility studies is that higher educated people have higher mobility rates. One aspect of this is that the mobility rates of the highly educated are less influenced by the business cycle. Mobility rates are generally pro-cyclical, i.e higher in boom years than in recession years.

[22] See Graversen et al. (2000) for comparative Nordic figures, Stimpson (2000) for Eurostat figures.

Figure 6.1: The inflow job-to-job mobility rates by age and educational level in Norway, 1988-98; pct.



The graph above shows that those with higher education are more mobile in both broad age groups. The age groups capture the "search phase" and the "stable phase" of a normal career. In addition comes the high mobility rates of particular educational groups in very high demand like ICT workers, medical doctors etc. They move more frequently because employers try to attract them with both material and intellectual incentives. This might cause too high mobility – too high transaction costs and wage inflation – neither optimal for the firms nor for society as a whole. For public policy makers such high mobility rates indicate that the public should increase long-term supply in order to get less rent-seeking and more real productivity.

6.1 The "massification" and feminisation of higher education

One of the truly strong secular trends in the economy has been the general rise in the education level. The number of university students has risen from 6-7000 in the late fifites to over 100.000. A significant part of this growth has been at the institutions on university level outside the big cities. The following graph, taken from Try 2000 illustrates this dramatic growth in the years 1987-1999.

Table 6.1: University level education by field of study 1987 -1999

Field of study	87	99	in %
Short, EDUCATION AND HUMANIORA	142 308	230 083	161,7 %
Short, ADM, ECONOMY, SOC.SCI AND LAW	91 831	174 693	190,2 %
Short, NATURAL SCIENCE AND TECHNOLOGY	62 483	80 999	129,6 %
Short, HEALTHCARE	57 144	78 931	138,1 %
Short, AGRICULTURE, FORESTRY AND FISHING	263	2 050	779,5 %
Short, SERVICES AND MILITARY	4 059	18 206	448,5 %
Total short (1 -3 years univ. level)	358 175	585 061	163,3 %
Long, EDUCATION AND HUMANIORA	13 931	22 445	161,1 %
Long, ADM, ECONOMY, SOC.SCI AND LAW	13 908	26 661	191,7 %
Long, NATURAL SCIENCE AND TECHNOLOGY	32 689	54 124	165,6 %
Long, HEALTHCARE	16 260	21 547	132,5 %
Long, AGRICULTURE, FORESTRY AND FISHING	4 139	5 476	132,3 %
Long, SERVICES AND MILITARY	1 849	4 585	248,0 %
Total long educations (4 years or more at univ. level)	82 776	134 838	162,9 %

This table shows that there has been strong growth in all fields. The real fast growers are all those fields of education with very low absolute numbers in 1987. Among the short educations Natural science and Technology and Health have had less growth than other fields, i.e the human oriented fields broadly speaking. In the case of the long educations, Natural science and Technology is close to the average.

The picture becomes more diversified if we look at males and females separately.

Table 6.2: University level education by field of study 1987 –1999 and by sex

	Female 87	Female 99	Female pct.	Male 87	Male 99	Male pct
Short, EDUCATION AND HUMANIORA	87 232	148 624	170,4 %	55 076	81 459	147,9 %
Short, ADM, ECONOMY, SOC.SCI AND LAW	39 211	85 698	218,6 %	52 620	88 995	169,1 %
Short, NATURAL SCI&TECH	5 408	13 606	251,6 %	57 075	67 393	118,1 %
Short, HEALTHCARE	52 564	70 760	134,6 %	4 580	8 171	178,4 %
Short, AGRIC, FORESTRY AND FISHING	29	580	2000,0 %	234	1 470	628,2 %
Short, SERVICES AND MILITARY	354	3 074	868,4 %	3 705	15 132	408,4 %
	184 798	322 342	174,4 %	173 290	262 620	151,5 %
Long, EDUCATION AND HUMANIORA	4 462	10 046	225,1 %	9 469	12 399	130,9 %
Long, ADM, ECONOMY, SOC.SCI AND LAW	2 808	10 132	360,8 %	11 100	16 529	148,9 %
Long, NATURAL SCI&TECH	2 909	9 935	341,5 %	29 780	44 189	148,4 %
Long, HEALTHCARE	4 195	7 825	186,5 %	12 065	13 722	113,7 %
Long, AGRIC. FORESTRY AND FISHING	523	1 446	276,5 %	3 616	4 030	111,4 %
Long, SERVICES AND MILITARY	23	203	882,6 %	1 826	4 382	240,0 %
	14 920	39 587	265,3 %	67 856	95 251	140,4 %

The fact that the number of males with short Natural science and Technology educations is growing slowly has no obvious explanation. To a large extent it is of course the consequence of being a large field in absolute numbers, but the starting point is about the same as for Humanities and Education and the Administration, Economy, Soc.sci category. One might ask if the innovative capabilities of the Norwegian economy would have been greater if more people had a natural science and technology education than administrative, social science, law etc. As shown in the report on IT for the European Observatory on Science and Technology, Ekeland 2001 the number of IT-graduates was stable during the nineties in Norway[23].

6.2 The sub fields of natural science and technology – an overview

As mentioned above the category of Natural science and Technology is divided into ten sub fields, however, two of these fields actually function as residual categories. The first one is 75000, the "headline" category "Natural science and Technology". There should according to the rules of the Norwegian statistical system not be persons registered with this educational code, but regrettably this has been a rather common practice. The second residual category is the real residual category, namely 759000.

Table 6.3: The relative shares of the major sub fields of study of natural science and technology.

NUS		87	99	87-pct	99-pct
750000	NATURVITENSKAP OG TEKNIKK (Natural science and technology, "headline")	9097	19308	9,6 %	14,3 %
751000	MATEMATISKE FAG (Mathematical)	6427	10438	6,8 %	7,7 %
752000	FYSISKE OG KJEMISKE FAG (Physics and chemistry)	4072	5244	4,3 %	3,9 %
753000	GEOGRAFISKE OG GEOLOGISKE FAG (Geography and Geology)	1461	1753	1,5 %	1,3 %
754000	BIOLOGISKE FAG (Bio-sciences)	2330	3961	2,4 %	2,9 %
755000	MASKINTEKNISKE FAG (Machine related subjects)	20620	23178	21,7 %	17,2 %
756000	ELEKTROTEKNISKE OG DATATEK FAG (Electronics and computer science)	19747	27619	20,7 %	20,4 %
757000	KJEMITEKNISKE FAG (Chemical subjects)	6465	11765	6,8 %	8,7 %
758000	BYGGE- OG ANLEGGSTEKNISKE FAG (Construction)	19332	21923	20,3 %	16,2 %
759000	NATURVIT OG TEKNISKE FAG ELLERS (Natural science and technology, not elsewhere classified)	5621	9934	5,9 %	7,4 %
	Sum total	95172	135123	100,0 %	100,0 %

[23] For a more detailed discussion of this, see Ekeland 2001, The supply and demand of high technology skills in Norway", report published by IPTS, the EU Joint Research Centre in Sevilla, Spain.

The relative shares of the major sub fields are rather stable. Not surprisingly there is a decline in Construction and Machine related subjects. The decline is relative the absolute number is increasing. Electronics and computer science has a stable share. Whether this is as it should be given the strong demand for these kinds of competencies is an open debate. Regrettably the increase is where it should not be, that is in the residual categories, particularly the “headline” category of “Natural science and technology” (750000). According to statistical rules, there should not be any concrete educations classified in these “headline” or “meta” categories, especially since there is a “not elsewhere classified” category (759000) where any cross- or interdisciplinary or “uncommon” educations should be put. That most of the growth is in the residual categories makes the classification much less useful for the analytical purposes the classification was supposed to serve.

Chapter 7. The role of technologists in the economy – a statistical overview

In this part of the paper we will use descriptive statistics in order to investigate the stocks and flows of technologists in the economy. There are of course many variables that one could use in such a description like education, age, sex, income, size of firm etc. We start off with comparing the technologist to other educational groups, first looking at the whole economy and then we will go into more detail. The aim is to get contrasting patterns that can say something about the labour marked mechanisms at play for the technologist in comparison with other groups. This is important in order to see whether the common sense intuition that the technologists are of special importance is at least not flatly contradicted by the labour market data. In this context educational variable used both to define the various groups and as a proxy for innovative competencies and is split in two levels:

- 1 – 4 years of higher education (University level 1 and 2)
- 5 years or more (University level 3 and PhD level)

The Norwegian classification of education makes it possible to have four different educational levels for those with tertiary education. The ISCED-97 classification also makes it possible to have a more detailed breakdown. Our view is that there are differences in the labour market conditions and the mobility patterns between those with 1-4 years of education and those with 5 years or more. Large groups like nurses, primary and secondary school teachers, and technicians have three or four years education and are roughly at the level of "lower academic degree". Above them are the long educations, formally certified in most cases by titles, and recognised as having a "higher academic degree". When it comes to fields of study we want to contrast the technologists with some other fairly homogenous professions. We think that medical personnel (nurses and doctors) and economists are both rather specialised groups, with well-defined labour markets and are useful for comparison besides the residual group of "other higher educations".

Table 7.1: The educational level of all employed persons, 1987 -1999

Year	Unknown	Primary Education	Craft certified	Secondary Education	High 1-4	High 5++	Total
1987	2,0 %	53,1 %	2,3 %	21,8 %	16,5 %	4,2 %	100 %
1988	2,2 %	51,6 %	2,6 %	22,6 %	16,7 %	4,3 %	100 %
1989	2,3 %	49,9 %	3,0 %	23,2 %	17,2 %	4,4 %	100 %
1990	1,7 %	48,2 %	3,5 %	23,6 %	18,4 %	4,7 %	100 %
1991	1,6 %	46,4 %	3,9 %	24,1 %	19,2 %	4,8 %	100 %
1992	1,7 %	44,7 %	4,3 %	24,5 %	19,9 %	4,9 %	100 %
1993	1,7 %	42,8 %	4,7 %	24,9 %	20,8 %	5,1 %	100 %
1994	1,5 %	41,2 %	5,2 %	25,3 %	21,5 %	5,3 %	100 %
1995	1,5 %	39,6 %	5,8 %	25,7 %	21,9 %	5,4 %	100 %
1996	1,7 %	38,9 %	6,2 %	26,6 %	21,2 %	5,5 %	100 %
1997	1,8 %	37,0 %	6,7 %	27,1 %	21,8 %	5,7 %	100 %
1998	2,0 %	35,2 %	7,2 %	27,6 %	22,1 %	5,8 %	100 %
1999	2,2 %	33,6 %	7,9 %	27,9 %	22,4 %	5,9 %	100 %

The previous table shows the very rapid increase in the overall level of education in a relatively short time span 1987 - 1999. The most striking fact is the decline of 20 percentage points in the share of the employees that have only primary education. There is a marked increase in Craft certification (fagutdanninger), but that is mostly due to the fact that a lot of new craft certificates have been established, not only the classical industrial ones. Further there is a rise in secondary education and in the 1-4 years of tertiary education. The share of the highest educated does increase but the increase is modest in comparison.

Table 7.2: The field of study of higher educated 1987 -1999, percent

Year	Other 1-4	Other 5++	Nat.sci 1-4	Nat.sci 5++	Econ 1-4	Econ 5++	Engin 1-4	Engin 5++	Med. 1-4	Med. 5++	Total
1987	38 %	8 %	4 %	3 %	13 %	1 %	12 %	5 %	13 %	3 %	100 %
1988	38 %	8 %	4 %	3 %	14 %	1 %	12 %	5 %	13 %	3 %	100 %
1989	38 %	8 %	4 %	3 %	14 %	1 %	11 %	5 %	13 %	3 %	100 %
1990	38 %	8 %	4 %	4 %	14 %	1 %	11 %	5 %	12 %	3 %	100 %
1991	39 %	8 %	4 %	4 %	15 %	1 %	11 %	5 %	12 %	3 %	100 %
1992	39 %	8 %	4 %	3 %	15 %	1 %	11 %	5 %	12 %	3 %	100 %
1993	40 %	8 %	4 %	3 %	15 %	1 %	10 %	5 %	12 %	3 %	100 %
1994	40 %	8 %	4 %	4 %	15 %	1 %	10 %	5 %	12 %	3 %	100 %
1995	40 %	8 %	4 %	4 %	15 %	1 %	10 %	5 %	12 %	3 %	100 %
1996	40 %	8 %	3 %	4 %	15 %	1 %	9 %	5 %	12 %	4 %	100 %
1997	40 %	8 %	3 %	4 %	15 %	1 %	9 %	5 %	12 %	4 %	100 %
1998	40 %	8 %	3 %	4 %	15 %	1 %	9 %	5 %	12 %	4 %	100 %
1999	41 %	8 %	3 %	4 %	15 %	1 %	9 %	5 %	11 %	4 %	100 %

The relative share of the various fields of higher education does not change much. There is a slight decline in the share of 1-4 years engineers, and 1- 4 year medical, but a closer analysis of these trends are necessary before conclusions are drawn. Since the engineers with 5 years of education or more is stable, this keeps up its share, and is it self not very alarming. We see the same tendency among the natural scientists. The share of lower educated decline, the higher raises. The technologists, defined as both the engineers and the natural scientists, have about a 20 % share of the higher educated.

Table 7.3: The field of study of those with long high educations 1987 -1999

Year	Other 5++	Nat.sci 5++	Econ 5++	Engin 5++	Med. 5++	Total
1987	37,5 %	17,1 %	3,1 %	25,8 %	16,5 %	100,0 %
1988	37,7 %	17,2 %	3,1 %	25,6 %	16,5 %	100,0 %
1989	37,7 %	17,1 %	3,1 %	25,5 %	16,6 %	100,0 %
1990	37,9 %	17,8 %	2,9 %	24,8 %	16,6 %	100,0 %
1991	38,4 %	17,6 %	2,9 %	24,7 %	16,4 %	100,0 %
1992	38,6 %	17,6 %	2,9 %	24,9 %	16,0 %	100,0 %
1993	38,7 %	17,4 %	2,9 %	25,3 %	15,7 %	100,0 %
1994	38,5 %	18,5 %	2,9 %	24,5 %	15,6 %	100,0 %
1995	38,3 %	18,5 %	3,0 %	24,4 %	15,8 %	100,0 %
1996	38,5 %	17,7 %	2,8 %	22,9 %	18,0 %	100,0 %
1997	38,8 %	17,5 %	2,8 %	23,1 %	17,7 %	100,0 %
1998	39,2 %	17,5 %	2,9 %	23,3 %	17,2 %	100,0 %
1999	39,8 %	17,4 %	2,9 %	23,0 %	16,9 %	100,0 %

If we take a closer look at only the highest educated we see no dramatic changes. The Engineers loose almost three percentage points in a situation where many policy makers would probably liked a slight increase. The important fact is, however, that the Natural scientists and engineers have a 40 % share of the highest educated. Whether this is as it should be is a difficult question.

On the one hand it is obvious that innovation, reengineering/imitation is important to keep up with other nations on the world market. To innovate or "reverse engineer" you need engineers. On the other hand some would argue that the less highest educated that is devoted to innovation the better, since the "meaning of life" is elsewhere, in entertainment, in good health, in an efficient and well educated private and public administration. The increase in the "Other fields" could be interpreted as a indication that Norway has the optimum number of engineers and that we are able to "allow" ourselves to use our intellectual resources not to produce goods and services demanding technological or natural science skills, but to enjoy life in various ways.

Table 7.4: The field of study of higher educated 1987 -1999, in 1000 persons

Year	Other 1-4	Other 5++	Nat.sci 1-4	Nat.sci 5++	Econ 1-4	Econ 5++	Engin 1-4	Engin 5++	Med. 1-4	Med. 5++
1987	118	23	11	10	41	1	36	16	39	10
1988	122	24	11	11	43	2	36	16	40	10
1989	123	24	11	11	45	2	36	16	40	10
1990	131	26	12	12	48	2	39	17	41	11
1991	137	27	13	12	52	2	39	17	43	11
1992	143	28	13	12	55	2	39	18	44	11
1993	153	29	13	13	58	2	40	19	45	11
1994	163	31	14	14	61	2	40	19	47	12
1995	167	31	14	15	63	2	40	20	48	13
1996	187	36	16	16	70	2	43	21	54	17
1997	191	38	16	17	71	2	43	22	55	17
1998	204	41	17	18	76	3	44	24	58	18
1999	212	43	17	19	78	3	45	25	59	18

The absolute numbers in the table above as expected tells us that there is an increase in all fields of study. The cumulative effect over twelve years is to roughly double the absolute number in each field of study. If we look at absolute size the 5++ engineers group is the largest group among the highest educated, about the same size as "Other fields". Economics is special in the sense that it has very few in the highest group and more than a lions share with 1-4 years.

Table 7.5: The field of study, higher educated, income 1987 -1999, percent

In 1000 NOK in 1999	Other 1-4	Other 5++	Nat. sci 1-4	Nat. sci 5++	Econ 1-4	Econ 5++	Engin 1-4	Engin 5++	Med. 1-4	Med. 5++	All
No Income	0,6	1,7	1,2	1,1	1,0	0,4	0,9	0,5	1,6	5,3	1,1
1..50	4,9	1,8	2,4	1,0	2,9	0,6	1,4	0,7	2,6	4,5	3,3
50..150	20,5	6,4	8,9	4,2	15,9	3,1	6,1	2,2	30,8	8,4	16,1
150..250	49,2	35,0	34,5	27,3	38,3	23,7	35,7	16,0	53,8	19,1	41,6
250..350	19,3	39,0	31,5	39,3	23,9	36,0	34,3	34,6	10,0	25,9	24,2
350..450	3,6	10,4	13,1	16,8	9,5	18,0	14,0	24,7	0,9	18,6	8,2
450..550	1,1	3,1	4,8	6,2	4,1	8,2	4,7	12,0	0,2	9,6	3,1
550..650	0,4	1,2	2,0	2,3	1,9	4,1	1,6	4,9	0,1	4,6	1,3
650..1 mill	0,3	1,1	1,5	1,5	1,9	4,5	1,1	3,8	0,0	3,7	1,0
> 1 mill.	0,1	0,3	0,2	0,3	0,5	1,3	0,1	0,6	0,0	0,3	0,2
	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

One of the indicators of a professional group's role in the economy is the income of that group. The table above holds no big surprises, but there are several interesting phenomena appearing when comparing different groups. We see that the engineers in the income classes above normal income (250 – 350 thousands NOK per year) are having the highest incomes of all educational groups with the exception of the group above 1 mill NOK where the economists take the lead. This is probably due to the few economists engaged on the stock exchange with particularly high earnings. However, this shows that engineers, the people that are directly involved in developing products and processes on the average earn more than other educational groups, even more than other professions with more market power like the Medical 5++. The Medical 5++ group has extensive market power due to their much tighter control with the supply of medical doctors. The Medical 5++ group also has a very high proportion of the lowest categories with income less than a living wage (below 150 thousand NOK). This distribution of the Medical 5++ is a new phenomenon, it dates from 1996, in the years before that the profile of this group is more similar to the other highly educated, i.e. very few in the first three income classes. Whether this change is due to changed registration routines or is caused by changes in the Medical 5++ group's adaption to the tax system is an interesting question, but not the theme of this paper.

Table 7.6: Field of study, higher educated, economic sectors, 1999, percent

Year, 1999	Other 1-4	Other 5++	Nat. sci 1-4	Nat. sci 5++	Econ 1-4	Econ 5++	Engin 1-4	Engin 5++	Med. 1-4	Med. 5++	Total
Goods producing	20	3	8	5	19	0	29	14	1	1	100
ICT sectors	11	2	12	8	19	1	32	15	0	0	100
Services (products)	37	3	5	2	35	1	11	3	2	1	100
R&D S&T	9	10	6	23	6	0	13	28	1	4	100
R&D Soc.	16	38	2	17	12	8	2	4	0	1	100
Services (humans)	36	8	2	3	13	1	6	3	23	5	100
Other Education	79	10	2	3	2	0	1	1	1	0	100
Universities	20	31	3	20	5	2	4	2	1	11	100

The table above shows the share the employees in each industrial sector of each educational category and we see that for both group of technologists, the natural scientists and the engineers there are diverse patterns both between the groups and according to the length of the education. These differences change somewhat in magnitude over the period, but the overall picture is roughly the same as in 1999.

The Nat.sci 1-4 years are not important for the R&D sectors. The Nat.sci 5++ is surprisingly well represented in the R&D Social science institutes. This might be explained by the fact that some of the regional R&D institutes have been – correctly or incorrectly classified as social science institutes. Some of them have departments working with for example environmental issues, where one typically needs both natural science and social science qualifications. We do not find the same pattern among the engineers. As expected the highest group of educated engineers is a very important educational group in the science and technology R&D.

As expected the technologists are also dominant in the ICT sectors. A curious phenomenon is that economists with 1 – 4 years have a substantial share of the employment in the ICT sector, in contrast to the highest educated economists that are not so important. However, one has to bear in mind that this latter group is a numerically much smaller group. This is indicated by the fact that it has the highest share of employment in social science R&D.

Table 7.7: Field of study, distribution over eight economic sectors, 1999, percent

Year, 1999	Other 1-4	Other 5++	Nat.sci 1-4	Nat.sci 5++	Econ 1-4	Econ 5++	Engin 1-4	Engin 5++	Med. 1-4	Med. 5++
Goods producing	7,8	5,9	28,9	15,1	15,4	9,8	37,9	35,0	1,6	2,0
ICT sectors	1,3	1,1	12,5	8,2	4,7	4,5	10,2	10,6	0,1	0,1
Services (prod.)	17,1	6,7	21,3	7,8	35,6	20,9	17,6	10,0	3,6	5,0
R&D S&T	0,3	1,4	1,9	8,4	0,4	1,5	1,6	5,8	0,1	1,4
R&D Soc.	0,1	1,2	0,1	0,8	0,1	3,7	0,0	0,2	0,0	0,1
Services (hum.)	39,8	55,1	26,9	34,4	41,1	48,0	30,5	32,4	92,9	84,9
Other Education	32,2	17,3	6,6	11,4	2,0	3,8	1,0	1,7	1,2	0,5
Universities	1,5	11,3	1,9	13,9	0,8	7,7	1,2	4,4	0,5	6,1
Sum	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

The above table shows the share of each sector of the total number of employees in an educational group. As a rule of thumb the different educational groups could be put in two groups, the “one major sector” and the “two major sectors” groups. The engineers have as expected a lions share in the goods producing and human services sectors. The natural scientists are more evenly distributed. This is in major contrast to the medical educations that are very concentrated into the services (humans), i.e. the health services. Also the “other fields” are heavily concentrated into services (humans). The S&T educations have large shares in the ICT sectors. This sectoral breakdown is a little bit to coarse since it is tailor-made to study the relationship between the research producing sectors, the two R&D sectors and the universities and their relation to the other “meta” sectors of the economy, with special focus on IT.

Table 7.8: Field of study, distribution over 20 economic sectors, 1999, percent

Year, 1999	Other 1-4	Other 5++	Nat. sci 1-4	Nat. sci 5++	Econ 1-4	Econ 5++	Engin 1-4	Engin 5++	Med. 1-4	Med. 5++	Of acad. empl.
Agriculture, forestry, fishing	1,4	1,6	1,5								1,0
Mining, oil extraction			5,1	6,3	1,8	2,9	3,5	9,2			1,8
Consumer goods			2,7		1,6			1,2			0,8
Wood, Pulp&Paper, chemicals	2,4	1,7	3,8	2,9	3,7	2,0	4,5	4,4			2,6
Metals, machinery (not ICT)							1,3				0,4
Other manufacturing n.e.c.			7,4	3,3	3,3	1,4	13,6	11,4			3,0
Energy and water			1,4			1,5	3,1	2,8			0,7
Construction			4,8	1,5	2,0		9,8	5,1			2,0
Computers&,electr equipt							1,3	1,6			0,3
Trade, hotels, restaurants	8,2	2,3	11,9	4,0	16,2	4,7	11,9	5,2	3,0	4,5	8,4
Transport, post, telefom	5,9	1,2	5,3	1,2	5,5	2,3	2,6	2,3			4,0
Telecom.			1,7		1,4	1,6	3,0	1,9			0,9
Financial intermediation	1,6	2,8	2,6	1,6	10,6	13,2	1,2	1,2			2,9
Other services	6,1	12,4	12,3	18,7	20,5	11,2	15,5	25,0		2,9	10,5
Computer services	1,2		11,6	6,8	3,7	3,1	6,3	7,8			2,7
Research institutes		2,6	2,1	9,0		5,4	1,6	5,7		1,6	1,3
Other community services	17,1	35,5	11,5	14,0	16,9	36,2	9,9	7,9	5,6	5,1	15,7
Other Education	33,7	18,3	7,0	11,5	2,4	3,9	1,2	1,7	1,4		16,9
Universities	1,4	11,0	2,0	13,0		7,1		3,7		6,0	2,7
Health	16,4	6,7	4,1	2,2	6,4	1,3	6,9		86,5	76,7	21,4
	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

In order to give a more immediate visual impression of the distribution of the various educations we have suppressed all shares less than 1%. The shaded column shows each sector's share of the higher educated employed persons.

Note that the medical educations are very concentrated. There are some nurses and pharmacists working in drugstores, that is why they have a substantial share in "Trade, hotels etc". Since this table reflects the traditional focus on manufacturing, the technologists look like they are in almost every branch, and indeed they are both in private sector and public sector, in research, indicating that they are needed everywhere in modern society.

One should note the share going into Mining and Oil, which is almost only oil extraction. This sector has a small share of total employment, but is very "engineer" intensive, clearly a sign that is technically advanced.

What is striking about the distribution is the large share for all four groups of technologists in the "Other services". Behind this rather neutral sounding title are three 2-digit NACE groups 71, 72 and 74.

Table 7.9: Field of study, selected 2-digit NACE sectors, share of employment, 1999

NACE sectors	Other 1-4	Other 5++	Nat. sci 1-4	Nat. sci 5++	Econ 1-4	Econ 5++	Engin 1-4	Engin 5++	Med. 1-4	Med. 5++	All higher
Real estate activities	0,5	0,7	0,7	0,5	2,4	0,9	1,0	0,7	0,2	1,3	0,8
Renting of machinery and equipment	0,1	0,0	0,2	0,1	0,3	0,1	0,2	0,1	0,0	0,0	0,1
Computers and related activities	1,2	1,0	11,6	6,8	3,7	3,1	6,3	7,8	0,1	0,1	2,7
Research and development	0,4	2,6	2,1	9,0	0,5	5,4	1,6	5,7	0,1	1,6	1,3
Other business activities	5,5	11,7	11,3	18,1	17,8	10,2	14,3	24,2	0,6	1,6	9,5
Public adm., defence, social security	11,7	27,4	8,6	11,8	13,9	31,7	7,7	6,7	4,8	4,5	11,8
Education	35,1	29,3	8,9	24,5	3,1	11,1	2,3	5,4	2,0	6,6	19,6
Health and social work	16,4	6,7	4,1	2,2	6,4	1,3	6,9	0,8	86,5	76,7	21,4
Sewage and refuse disposal	0,1	0,1	0,4	0,3	0,1	0,0	0,4	0,4	0,0	0,0	0,1
Membership organizations n.e.c.	1,8	5,7	0,7	1,0	1,3	4,0	0,5	0,5	0,4	0,4	1,6
Recreation, culture& sport	3,1	2,3	1,6	0,8	1,3	0,4	1,2	0,3	0,1	0,1	1,9

The table above shows clearly that it is NACE 74 "Other *business* services" that mainly make up the major share of the aggregated sector "Other services". The other two are marginal. If we then look at the sector 74 in more detail it consists of 19 four- or five digit sectors. To keep it simple we look at both nat.sci 5++ and engineers 5++ together. There are 19 sectors at the most detailed level, but five of them have 85% of the employment. Actually there are three major and two minor sectors.

Table 7.10: The most technologist heavy sub sectors of NACE 74

74201	17,5 %	ARCHITECTURAL ACTIVITIES
74202	22,6 %	CIVIL ENGINEERING ACTIVITIES
74203	5,3 %	GEOLOGICAL SURVEYING
74209	31,0 %	OTHER TECHNICAL CONSULTANCY ACTIVITIES
74300	9,5 %	TECHNICAL TESTING AND ANALYSIS

Note that four of these are five digit sectors, that is national classifications that are not part of the international standard. The two largest ones are rather residual in their character "Civil engineering activities" and "Other technical consultancy activities". One might ask why it was necessary to have two such residual-sounding categories. And especially the "civil engineering activities" sounds like it is defined by the kind of education needed and not the activity.

Table 7.11: The firm size of the major sub sectors of NACE 74

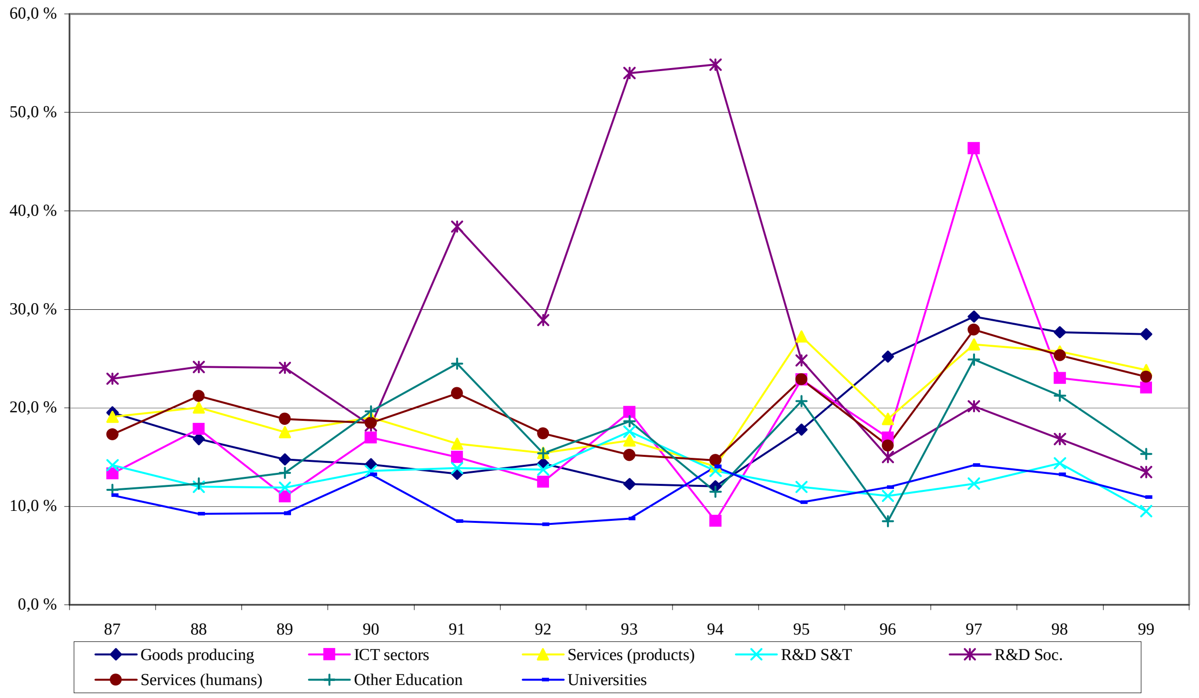
Firm size	No empl.	Share of empl	All share
One man firms	3057	10,9 %	36,0 %
2 - 9 empl.	6349	22,7 %	48,0 %
10 -49 empl.	8986	32,1 %	13,7 %
50 -99 empl.	2957	10,6 %	1,4 %
100 - 249 empl.	3019	10,8 %	0,6 %
> 250 empl.	3655	13,0 %	0,3 %
Sum	28023	100,0 %	100,0 %

The previous table shows that one third of the employment is in firms with 1 - 9 employees, another third in firms with 10 – 49 employees. This structure is only marginally changing if we look at technologists and other fields of study, if we control for level of education etc. As a share of the number of firms the small ones are as usual dominating. It might be added that this sector has been very rapidly growing from around 13.500 employees ten

7.1 The mobility of technologists

In this section we are going to explore some statistical aspects of the mobility of technologists. We will aim both at comparing the mobility of technologists with other fields of study and to look at different sub groups of mobility. There are several problems with the data that has been dealt with elsewhere (Ekeland and Bugge, 2001).

Figure 7.1: Overall job-to-job mobility, 1987 - 1999, eight sectors



The figure below illustrates this by showing the abnormal high rates of the Social Science sector. These are caused by two factors. One factor is the reorganization of parts of the research sector in the process of joining the former five research councils into one unified council. The other factor is a change of the firm number system.

Another striking phenomenon is the peak in the ICT sector from 1996 1998 - the start of the dot.com years. To a certain extent this is also caused by statistical errors, but we believe it reflects the very high turnover in the ICT sector in those years. We see, however, that there is certain ”jumpiness” in the other sectors too. As already mentioned this is caused by the change in the firm ID number system.

There are fluctuations from year to year that are not easily explained, and of course the fact that the bigger the sector, the ”smother” are the rates. Although the lines do cross each other one can clearly see that some sectors have a lower/higher mobility rate. The products and service sectors have a declining mobility rate from 1988-1989, the start of the downturn after the hectic 1986-1987. From 1994 these sector experience an upturn. Universities and natural science R&D are as expected very stable, they should not be so much influenced by business cycle.

In the years 1997 - 1999 there are less dramatic changes. One might guess that the economy is slowing down relatively and that a lot of those who moved in the upturn have settled a bit more. In the following we will use 1999 as a year for cross-sectional analysis.

Table 7.12: The overall job-to-job mobility rates, eight sectors.

Deliv.\Receiv.	Goods prod.	ICT	Serv. (prod.)	R&D S&T	R&D Soc.	Serv. (hum)	Other Educ.	Univ.	Same Job
Goods producing	21,8	0,2	3,0	0,0	0,0	2,3	0,2	0,0	72,5
ICT sectors	4,6	11,1	3,1	0,2	0,0	2,8	0,1	0,1	78,0
Services (products)	2,3	0,5	16,6	0,0	0,0	4,0	0,4	0,0	76,2
R&D S&T	1,4	1,0	0,9	2,2	0,1	2,9	0,3	0,8	90,5
R&D Soc.	0,5	0,3	1,2	0,5	3,0	5,8	0,2	2,1	86,5
Services (humans)	1,5	0,3	2,6	0,1	0,0	17,3	1,2	0,1	76,8
Other Education	0,7	0,1	1,2	0,0	0,0	5,3	7,9	0,2	84,7
Universities	1,0	0,5	0,8	0,6	0,3	5,2	0,9	1,6	89,1

The table above show the mobility of all groups' job-to-job mobility. The rate of mobility is rather high. Four of the sectors have more than 20% mobility rate. Least mobility can be seen from the R&D S&T sector, where only around 10% change jobs, even less than from the Universities where one should expect low mobility. One third of those who are mobile go to the services (humans), more than 20% of the mobility is internal. One must be aware of the mechanism that the more narrow the sector, the more of the mobility will be to other sectors. If you define the whole economy as one sector – then all mobility will be internal to the sector. For R&D Soc. and R&D S&T (which are equally "narrow") the same tendency appears, that services (humans) has a higher share of the mobile persons than the sector itself. Sectors like goods producing and services (humans) are in fact large aggregates, so comparing them to the two R&D sectors must be based on an understanding of the difference between those two entities. That does not mean that is not significant that there is very little mobility from the goods producing sector to the ICT sector. The relative share from R&D S&T is five times as high, but of course the numbers are small.

Table 7.13: Engineers 5+ in sectoral averages 1987 - 1999

Sector	Goods prod.	ICT	Serv. (prod.)	R&D S&T	R&D Soc.	Serv. (hum)	Other Educ.	Univ.	Same Job
Goods producing	11	1	2			3			83
ICT sectors	3	11	3	1		2			79
Services (products)	5	2	8			4			81
R&D S&T	4	1	1	3		3		2	86
R&D Soc.	2	1	1	4	6	11	1	5	68
Services (humans)	4	1	1			11			83
Other Education	2	1	1			5	6	4	81
Universities	3	1	1	5	1	5	1	2	81

There is a surprisingly even level of mobility – between 15 – 20 % roughly speaking, with the exception of R&D Soc. As mentioned above, there is a lot of noise in this particular sector. Social science R&D institutes has been wrongly classified on a large scale, definitions have changed etc. Still it is not contrary to what is to be expected that engineers in R&D Soc. should be mobile. The wages are lower in that sector and it is not the culture that most engineers were socialised into during their studies etc. We still believe that the rate is too high. It should probably have been closer to 20%, more in line with the mobility of the engineers 5+ going from R&D S&T, but somewhat higher.

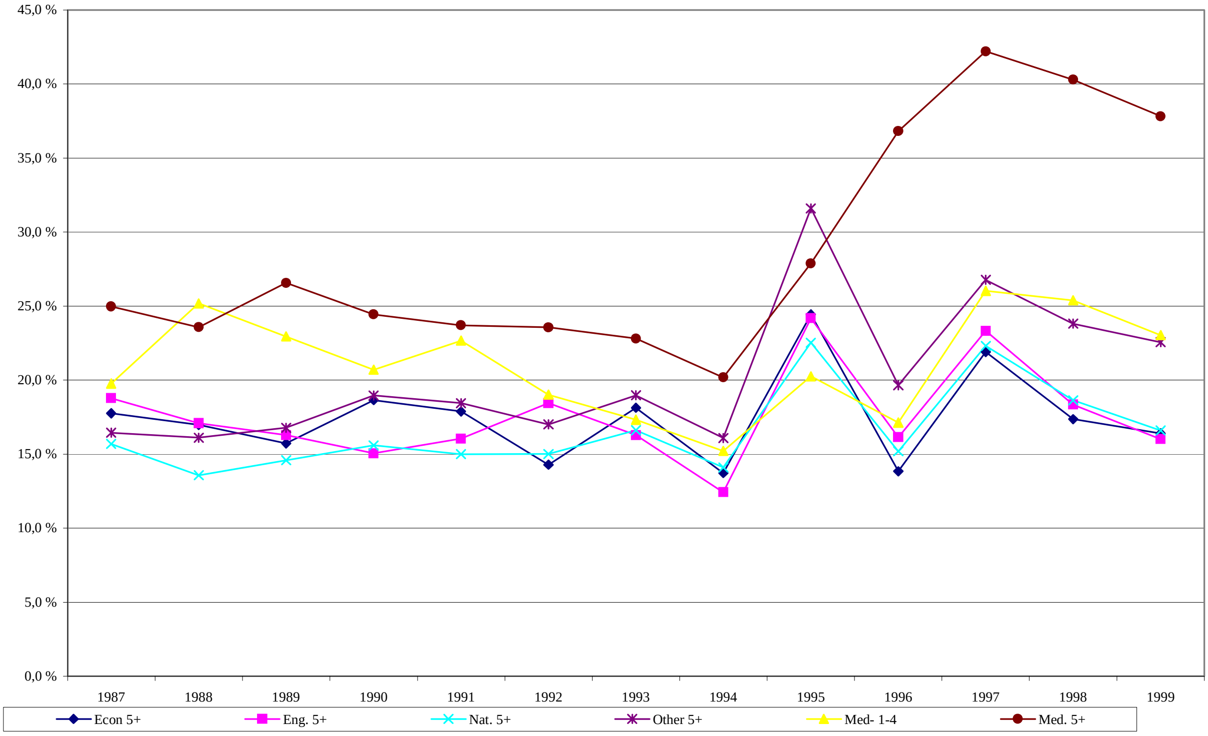


Figure 7.2:Mobility rates of six different sectors, years 1987-1999, percent

The figure above clearly shows that the medical 5+ have a much higher mobility, and for some reason it really peaks in the late nineties. That might be organisational changes, but that is not obvious, since the medical 1 - 4 years have mobility rates of the same order of magnitude as the other 5+ groups. The rates for the medical 5+ are not fluctuating as much from 1995 onwards as for the other groups, and that is as expected since they mostly work in hospitals, that is large and organisationally stable workplaces.

7.2 The mobility of technologist and R&D

In this part we want to investigate if there is any obvious connection between the mobility of technologists and the R&D expenditures in different sectors. To do this we use the latest Norwegian R&D Survey done by statistics Norway from 1999. That survey have data for internal R&D, external R&D and some categories of innovation costs. There is a large degree of correlation between these measures. Those branches with high internal R&D costs also have high external R&D costs and other innovation expenditures.

Table 1 R&D costs according to the Norwegian R&D survey, 1999

	Sector	External R&D	Internal R&D	Innovation costs	No of empl	All cost per empl.	R&D costs per empl.	Int. R&D per empl.
Fish farming	5	184880	169426	31689	4265	91	83	40
Mining	10,12-14	10906	8868	2716	3224	7	6	3
Oil and Gas	11	2049060	781024	1450270	22049	194	128	35
Food&Beverages	15-16	195117	159006	209230	47556	12	7	3
Textile	17-19	26773	24739	3552	5727	10	9	4
Wood	20	28022	24456	6558	12748	5	4	2
Pulp&Paper	21	251963	168837	95153	8870	58	47	19
Publ.&Print.	22	45487	43262	13041	32536	3	3	1
Chemicals	23-24	1290312	940651	391462	17402	151	128	54
Rubber&Plastics	25	99859	70447	31398	6372	32	27	11
Glass, cheramics etc	26	83135	61224	61664	8144	25	18	8
Basic Metals	27	465874	358646	218288	13708	76	60	26
Metal products	28	85209	73760	14305	16034	11	10	5
Machinery&Equip.	29	647269	569178	136616	20884	65	58	27
Electrical&Optical	30-33	1921300	1809602	239725	19475	204	192	93
Transp. equip.	34-35	365526	290107	146878	36317	22	18	8
Furniture and n.e.e.	36-37	90923	80174	32153	12564	16	14	6
Electr.&Water	40-41	124874	80309	102941	16318	19	13	5
Construction	45	66885	51783	22769	38540	4	3	1
Wholesale trade	50-55	425876	346281	117306	80410	11	10	4
Telecoms	64.2	846127	747774	407463	105712	19	15	7
Finance&Insurance	65-67	219254	196004	81385	43419	11	10	5
Biz.serv.&Computing	70-74	2663692	2438799	465963	44285	126	115	55
Culture&Sport	92.2	9901	2751	7150	6075	3	2	0
Sum total		12198225	9497108	4289675	622634	1959	42	35

There are very marked differences between the sectors, they are of order of magnitude. Often one uses the "R&D intensity", often calculated as the share of internal R&D costs of total sales. A better measure would be value added, but that kind of data is often hard to get and total sales are used in stead. Another possibility would be to use R&D cost per employee which also strongly correlated to both sales and value added. In this particular case we choose to use the R&D costs per employee, since we find the total sales figures to be less reliable.

There are several reasons for this all connected to the fact that the unit of selection neither the establishment (local unit of production), nor the enternprise (the legal unit), but the “branch unit”. That is the establishments in of an enterprise with the same NACE code disregarding geographical location. It is my impression that the respondends have had problems with giving the correct sales figures and that several units have answered for the whole “branch unit” inflating the numbers.

When it comes to the sectoral breakdown it is special selection of sectors[24]. First of all public sector is excluded since this is “business R&D”. All firms with less that 10 employees are excluded, there is a random, stratified selection of firms with 10 - 49 employees, and a full cencus of all large firms. In construction (Nace 45) all firms with less that 50 employees are excluded. The general principle of the breakdown is an “aggregate 2-digit NACE”. There are 27 sectors, most of them composed of two or three 2-digit sectors. Then there is some exceptions. In NACE 64, post and telecoms, only telecoms are included. In NACE 92, only TV and radio activities are included although the title “Culture and sports” usually covers a larger part of NACE 92.

The choices made can of course be discussed at length, but we will just take the data as the best there is. The overall picture is probably correct, but there are several problems with definitions of R&D as such, and more mundane problems of data collection.

We have tried to use the same definitions and cut-offs to the register data and ended up with a total population of 603 thousand persons. We “added” the condition that it should be “full time” workers, defined as earning at least 150.000 NOK per year. This in order to clean the data for the very, very mobile young part-time workers like pupils and students since the use of part-time work is unevenly distributed among industrial branches. A limit of 150.000 NOK might on possibly bias those adults - women in general - that are working 50-60% part-time, but who are obviously part of the stable, adult workforce.

In addition we know from experience that part-time youth are often not included when people answer questionaires about the number of employees. That the size of the population fram the R&D survey and the registerdata with our “added” constraint are of roughly the same size also indicates this. For the purpose of looking at the relation between mobility of innovative competences and R&D, the exlusion of the ultra-mobile youth and possibly some adult part-timers do not introduce any serious biases.

[24] There exist at the time of writing no written documentation of the 1999 R&D Survey. The following is based on the documentation of the 1997 survey and oral communication with Statistics Norway. The sectoral breakdown has been changed from 1997 to 1999.

7.2.1 Expected results

Before we start out looking at the actual data, a few words about what one might expect to find. As outlined in the introductory parts an optimal level of mobility is one that avoids the extremes. Since a part of the working population goes out of the workforce and into maionly ino retirement, but also other “destinations”. There will be a certain mobility just in order to replace them. If average working life is estimated to 35 years and each retirment meant a job-to-job shift for some other person that would imply a little less than 3% mobility. Reality when it comes to retirement, replacement and mobility is much more complex. If there is a turnover of 25 %, every fourth person leaves every year - that very often implyes high training costs, too little knowledge accumulation. So the rule of thumb is that less than 5% or higher than 25% is too “extreme”. Some think that the upper limit shoul be 20% - that is still a rather high turnover.

One should also expect that knowledge intensive work, work with higher training costs have lower turnover, than less complex work where productivity and innovation (technical, organisational) might not suffer that much from high turnover. One might also argue that one is more attached to a knowledge intensive and intelectually challenging job. If this is correct then the more R&D intensive sectors should tendentially have lower mobility rates. Of course there are many counteracting tendencies: well educated people seeks more new challenges, less educated are more satisfied with a job they master, the labour marked is competing more for highly skilled, raising wages etc. To take part in that you very often have to change job to the “new openings”, those new sectors that have to raise wages to indicate their need for highly skilled people. All these opposing tendecies might have as a result that there is no “extreme” patterns in the mobility, the system has enough checks and balances to keep mobility within certain limits. A closer more detailed study of individual sectors - trying to controll for various of these factors might then give another result. But that kind of analysis will not be attempted here. We will look for the major trends in the data.

Whith this much higher number of sectors the mobility matrix becomes very hard to read. The human mind cannot grasp 250 - 300 numbers in a table. In order to highlight patterns and supress detail we have chosen to only show those numbers that are above 1%. This seems to be a reasonable trade-off between detail and overview, favouring the latter. In the case that 90% of the employed in a sectors have the same job from one year to another, this 1% rule impolies that shares of the mobile less than 10% are not shown.

Table 2 All employed, full time job to job mobility, average 1987 - 1999, N = 600.000 in 1999

	Fish farming	Mining	Oil and Gas	Food&Beverages	Textile	Wood	Pulp&Paper	Publ.&Print.	Chemicals	Rubber&Plastics	Glass, cheramics	Basic Metals	Metal products	Machinery&Equip.	Electrical&Optical	Telecom	Furniture and n.e.e.	Electr.&Water	Construction	Wholesale trade	Transport&Com.	Finance&Insurance	Biz.serv.&Comp.	Culture&Sport	Same Job
Fish farming	8			7																2	1				78
Mining		4																							91
Oil and Gas			10																	1			1		86
Food&Beverages				6																1					90
Textile					6																				90
Wood						7																			89
Pulp&Paper							5																		92
Publ.&Print.								7															1		90
Chemicals			1						5																91
Rubber&Plastics									1	4															90
Glass, cheramics etc											4														91
Basic Metals												4													92
Metal products													5	2		2									86
Machinery&Equip.														6		1							2		87
Electrical&Optical															8					2			2		86
Transp. equip																8									85
Furniture and n.e.e.																	6								89
Electr.&Water																		8							89
Construction																			8						87
Wholesale trade																				8			2		86
Transport&Com.																					12		1		84
Finance&Insurance																						11			87
Biz.serv.&Computing																				2			11		81
Culture&Sport																							1	5	91

We start out with the overall picture in order to have a baseline for looking at the higher education groups and when comparing individual years. This table shows that most of the job to job mobility is inside the same sector, but one has to remember that a all shares of mobility less than 5% has been surpressed. But it is not contrary to common sense that fish farming should have a strong mobility to primarily the Food&Beverages sector. We also note that the new knowledge instensive services Biz.services and Computing are attracting worker, that is growing. The same goes for retail trade.

Table 3 Engineers 1 - 4 years , full time, job to job mobility, 1999, N = 27.000

	Fish farming	Mining	Oil and Gas	Food&Beverages	Textile	Wood	Pulp&Paper	Publ.&Print.	Chemicals	Rubber&Plastics	Glass, cheramics	Basic Metals	Metal products	Machinery &Equip.	Electrical &Optical	Telecom	Furniture and n.e.e.	Electr.&Water	Construction	Wholesale trade	Transport &Com.	Finance&Insurance	Biz.serv.& Computing	Culture&Sport	Same Job
Fish farming	5			14																					81
Mining		2																					6		92
Oil and Gas			9																						87
Food&Beverages				4																2			2		89
Textile					12								2		2								2		83
Wood						10																			84
Pulp&Paper							15								2										79
Publ.&Print.								13															4		81
Chemicals									5																91
Rubber&Plastics										8			1	1						4			1		84
Glass, cheramics etc									2		3								2				1		90
Basic Metals																									97
Metal products													3	2		2							2		90
Machinery&Equip.												1		5						1			1		89
Electrical&Optical															10					3			4		82
Transp. equip															1	14					1		2		80
Furniture and n.e.e.															1		3			1					91
Electr.&Water																		21							77
Construction																			5		1		1		91
Wholesale trade																				9			4		83
Transport&Com.																			1		7		3		87
Finance&Insurance																					1	4	4		90
Biz.serv.&Computing														4									10		82
Culture&Sport																								1	98

Here we show as similar table for the Enginneers 1 - 4 years or education. The overall pattern are the same, but we se an even stronger tendency for going int to biz.services and computing. The reason why whole sale trade gets such a inflow from various sectors is not so easy to explain. It might be the case that this salesmanship has become more engineerr skill demanding .

In the case of fish farming the mobility internal to the secotor (the diagonal number) do not have the lions share of the mobility. Generally is a less internal mobility.

Table 4 Engineers 5 years or more , full time, job to job mobility, 1999, N = 18.000

	Mining	Oil and Gas	Food&Bevera ges	Textile	Wood	Pulp&Paper	Publ.&Print.	Chemicals	Rubber&Plast ics	Glass, cheramics etc	Basic Metals	Metal products	Machinery& Equip.	Electrical&O ptical	Telecom	Furniture and n.e.e.	Electr.&Wate r	Construction	Wholesale trade	Transport&C om.	Finance&Insu rance	Biz.serv.&Co mputing	Culture&Spor t	Same Job
Fish farming																								100
Mining	10		2			4		2														4		78
Oil and Gas		14																						83
Food&Beverages			6																1		1	1		89
Textile				8															8					83
Wood					13																2	2		82
Pulp&Paper						13		1					1						1					81
Publ.&Print.							12	2						2								8	2	75
Chemicals								5	1													1		90
Rubber&Plastics									3				1	1	1				3			4		87
Glass, cheramics etc									1									2				3		91
Basic Metals								2			2											1		92
Metal products								2											3			6		85
Machinery&Equip.											2	1	4		1							3		87
Electrical&Optical														9					2			5		82
Transp. equip														2	12							4		78
Furniture and n.e.e.										5	2					2						2		88
Electr.&Water																	21			2				75
Construction														3				5				2		89
Wholesale trade		2												1					3			5		86
Transport&Com.																				4		3		91
Finance&Insurance																				2	7	5		85
Biz.serv.&Computing													3									7		86
Culture&Sport																			5				5	91

We note that whole sale trade “looses” enginneers to oil&Gas and biz.serv.&computing, Since the stable job rate is 86, the “visible” mobility sums to 11 that means that the inflow mobility is rather concentrated. When more than two thirds of the mobiity is visible and concentrated to a few sectors we call it concentrated.

Table 5 Natural scientists 1 - 4 years, full time, job to job mobility, 1999, N =10.000

	Fish farming	Mining	Oil and Gas	Food&Beverages	Textile	Wood	Pulp&Paper	Publ.&Print.	Chemicals	Rubber&Plastics	Glass, cheramics etc	Basic Metals	Metal products	Machinery&Equip.	Electrical&Optic.	Telecom	Furniture +nec.	Electr.&Water	Construction	Wholesale trade	Transport&Com.	Finance&Insurance	Biz.serv.&Comp.	Culture&Sport	Same Job
Fish farming	15			20																2					63
Mining		11																					11		78
Oil and Gas			7																				1		90
Food&Beverages				5																			2		90
Textile					13																				87
Wood						16														2			4		78
Pulp&Paper							8								1										91
Publ.&Print.								13													3		4		81
Chemicals									5														2		90
Rubber&Plastics				2						8					2					6					82
Glass, cheramics etc							2				2			2	2					2		2	2		89
Basic Metals										1		4									1				94
Metal products													3	2					2		2		3		88
Machinery&Equip.				1								3		5		3				1			3		83
Electrical&Optical															9					2			4		83
Transp. equip															1	11					2		2		83
Furniture and n.e.e.														2			8			2			3		85
Electr.&Water																		19			2		2		76
Construction																			5		2		2		89
Wholesale trade																				9	2		7		78
Transport&Com.																					13		5		80
Finance&Insurance																						8	3		89
Biz.serv.&Computing														1						1			11		83
Culture&Sport																								1	98

We are getting used to the general pattern that people drifts from the traditional industrial sectors and into the new service sectors, and that there is some further redistribution. Biz.servcises&Computing recruit broadly (column), but persons from that branch also go into machinery&equip. and wholesale trade to a certain limited degree. Most of the mobility is internal to Biz.servcises&Computing.

Table 6 Natural scientists, 5 years or more , full time, job to job mobility, 1999, N = 8.700

	Mining	Oil and Gas	Food&Beverages	Textile	Wood	Pulp&Paper	Publ.&Print.	Chemicals	Rubber&Plastics	Glass, cheramics etc	Basic Metals	Metal products	Machinery&Equip.	Electrical&Optical	Telecom	Furniture and n.e.e.	Electr.&Water	Construction	Wholesale trade	Transport&Com.	Finance&Insurance	Biz.serv.&Comp.	Culture&Sport	Same Job
Fish farming			25																			6		69
Mining								50																50
Oil and Gas		16																						82
Food&Beverages			5																5			5		85
Textile				67																				33
Wood					8															8				83
Pulp&Paper			5			9		5											5			9		68
Publ.&Print.			1				9													1	1	3		84
Chemicals								4											1			2		91
Rubber&Plastics									11															89
Glass, cheramics etc																								100
Basic Metals											4											2		95
Metal products								4				4	4									4		85
Machinery&Equip.								1			1	1	1	1	2				1			6		85
Electrical&Optical														5					1			6		86
Transp. equip														3	14							5		76
Furniture and n.e.e.	8															17						8		67
Electr.&Water																	21			2		1		76
Construction														2				6				2		90
Wholesale trade																			7			7		82
Transport&Com.																				10		6		83
Finance&Insurance																					12	1		87
Biz.serv.&Computing													2									13		83
Culture&Sport																							6	94

Again we se the same overall pattern, but we also se that we get "jumpy" numbers as a 50% mobility in mining. The reason is obvious, with less than 9.000 persons, some sectors become very small. In fact only 6 - six - persons are natural scientist with 5+ and then the noise dominates.

Table 7 Natural scientists, 5 years or more , full time, job to job mobility, 1987 - 1999, N = 80.000 (sum of all years)

	Fish farming	Mining	Oil and Gas	Food&Beverages	Textile	Wood	Pulp&Paper	Publ.&Print.	Chemicals	Rubber&Plastics	Glass, cheramics	Basic Metals	Metal products	Machinery&Equip.	Electrical&Optical	Telecom	Furniture and n.e.e.	Electr.&Water	Construction	Wholesale trade	Transport&Com.	Finance&Insurance	Biz.serv.&Comp.	Culture&Sport	Same Job
Fish farming	5			3																2			5		83
Mining		3	2						3	1	1			1									7		80
Oil and Gas			9																	1			1		88
Food&Beverages				6																2			4		86
Textile					25					3				6	3						3				61
Wood						6													2		1		3		85
Pulp&Paper				1		1	5		2														1		87
Publ.&Print.								7												1			4		87
Chemicals			1						6														2		90
Rubber&Plastics			3						11	3										1					79
Glass, cheramics etc		2									5									1			5		84
Basic Metals												4											2		91
Metal products												1	3	5									4		84
Machinery&Equip.														6		2				1			10		78
Electrical&Optical															7					3			7		82
Transp. equip			1											1	1	9							6		79
Furniture and n.e.e.						2											7			2			7		77
Electr.&Water																		9					3		86
Construction															1				4				2		92
Wholesale trade			3												1					7			6		80
Transport&Com.																					11		7		79
Finance&Insurance																						14	2		83
Biz.serv.&Computing																							12		84
Culture&Sport															1					2	2		6	2	85

Looking at the same group, natural scientists, but over the whole period gives a different picture, because now the oil&gas sector shows its importance. That is of course what we should expect and only shows that 1999 was a special year for the oil&gas sector with oil prices diving and widespread belief that the market power of the OPEC cartell was gone. Consequently - few job openings and low mobility.

Table 8 All other fields 1 - 4 yrs , full time, job to job mobility, 1987 - 1999, N = 36.000 in 1999

	Fish farming	Mining	Oil and Gas	Food&Beverages	Textile	Wood	Pulp&Paper	Publ.&Print.	Chemicals	Rubber&Plastics	Glass, cheramics	Basic Metals	Metal products	Machinery&Equip.	Electrical&Optical	Telecom	Furniture& n.e.e.	Electr.&Water	Construction	Wholesale trade	Transport&Com.	Finance&Insur.	Biz.serv.&Comp.	Culture&Sport	Same Job
Fish farming	9			6																3	4	2	3		72
Mining		3									2							1			1		2		87
Oil and Gas			10																	1			1		86
Food&Beverages				6																2	1		1		87
Textile					14															1	1		1		79
Wood						11														1			1		82
Pulp&Paper							5													1			1		90
Publ.&Print.								8															2		89
Chemicals			2						5											1					90
Rubber&Plastics									7	3										1			1		83
Glass, cheramics etc											11									1			2		80
Basic Metals												4											1		90
Metal products													5	2		2					1		2		83
Machinery&Equip.														5		1				1			3		86
Electrical&Optical															8					3			4		80
Transp. equip																8					3		2		83
Furniture and n.e.e.																	12			1			1		82
Electr.&Water																		10					1		85
Construction																			5		1		3		87
Wholesale trade																				8	1		4		83
Transport&Com.																					13		2		84
Finance&Insurance																						12	2		85
Biz.serv.&Computing																				2	2	1	12		79
Culture&Sport								1																7	90

There is a marked “emptyness” in the lower diagonal part. Chemical gives to oil&gas, culture to publishing and printing and the expanding biz.serv&computing has some interaction with the other expanding services, the detailed patterns are probably rather complex. If we compare this with the natural scientists there are a obvoius difference regarding mobility to the oil&gas sector.

Table 9 All other fields 5 years or more , full time, job to job mobility, 19987 - 1999, N = 65.000 (whole period)

	Fish farming	Mining	Oil and Gas	Food&Beverages	Textile	Wood	Pulp&Paper	Publ.&Print.	Chemicals	Rubber&Plastics	Glass, cheramics etc	Basic Metals	Metal products	Machinery&Equip.	Electrical&Optical	Telecom	Furniture and n.e.e.	Electr.&Water	Construction	Wholesale trade	Transport&Com.	Finance&Insurance	Biz.serv.&Computing	Culture&Sport	Same Job
Fish farming	5			8																3		2			79
Mining		9										2						2		4			2		80
Oil and Gas			7																	2			1		88
Food&Beverages				7																2			1		88
Textile					5											1					1		1		92
Wood						11														1			2		83
Pulp&Paper						2	4											1		2			2		88
Publ.&Print.								7															2		90
Chemicals			3						4													1	2		89
Rubber&Plastics									15	1		1								3		1	1		73
Glass, cheramics etc				2							2											2	4		88
Basic Metals										1		4													89
Metal products									2				2	5						2			3		79
Machinery&Equip.														6		1				1			9		79
Electrical&Optical															7					3	1		6		80
Transp. equip														2		6					2		4		83
Furniture and n.e.e.															2		24			4					66
Electr.&Water																		8					1		89
Construction																			2				2		94
Wholesale trade				1																5			2		88
Transport&Com.																					9		3		86
Finance&Insurance																						10	2		87
Biz.serv.&Computing																							27		70
Culture&Sport																							1	3	94

Looking at these patterns one must keep in mind that we are looking at industrial and business service sectors and that the public sector and important services like post is excluded. This is a minority of the in it self very heterogenous residual group “Other fields”. It confirms the over pattern of the growth of service sectors. That growth takes place both by these sectors recruiting directly from the young entrants to the labour marked, but also - since there is a need for experience and competences - from other branches. The number of persons is small in several branches. That means that mergers, firms reclassified plays a role. That is maybe why for example the interenal mobility in rubber&plastics is only o9ne percent and mobility to other branches, especially chemicals is relatively high

Table 10 Medical, 5 years or more , full time, job to job mobility, 1999

	Food&Bevera	Pulp&Paper	Publ.&Print.	Chemicals	Electrical&O	Telecom	Construction	Wholesale	Finance&Insu	Biz.serv.&Co	Same Job	SUM
Fish farming	4										2	6
Oil and Gas											22	22
Food&Beverages	2										21	23
Textile											1	1
Wood											1	1
Pulp&Paper		1									7	8
Publ.&Print.			1								5	6
Chemicals				7			1	1	1	1	146	157
Glass, cheramics etc				1							3	4
Basic Metals											11	11
Machinery&Equip.											3	3
Electrical&Optical					1	1					2	4
Transp. equip						1					9	10
Furniture and n.e.e.											2	2
Electr.&Water		1									2	3
Construction											2	2
Wholesale trade				3				15		4	144	166
Transport&Com.								1			17	18
Finance&Insurance										1	19	20
Biz.serv.&Computing	1		1	3				4		21	361	391
Culture&Sport											4	4
SUM	7	2	2	14	1	2	1	21	1	27	784	862

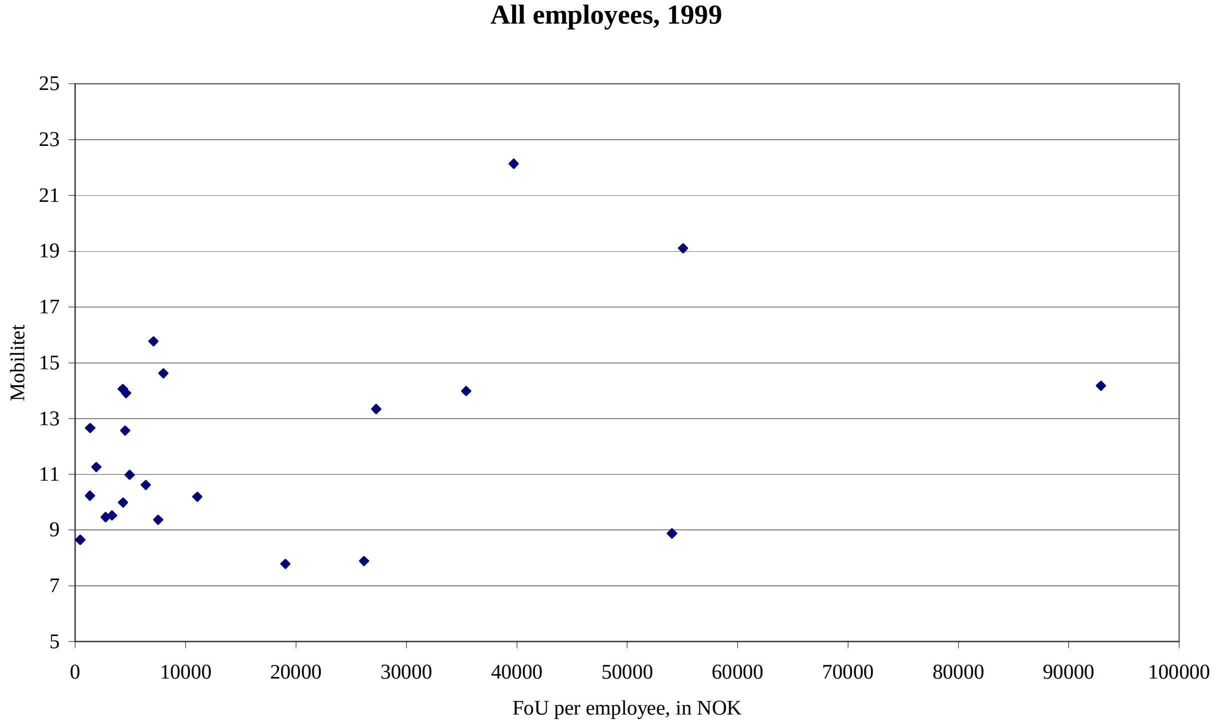
We round of this part on the sectoral mobility patter with looking at the medial 5+. First of all the number of sectors is very different. Secondly; it is only three major branches involved: chemical, wholesale trade and the eternal business services & computing. Only these three sectors do have more than a handfull or two of this educational category. In the other branches it might just be that the big firms have their own doctor to take care of their personel; meaning that they have no real role in the innovative processes in that sector.

The high density of medical doctors in chemicals is because pharmaceuticals is a sub sector of chemicals, in wholesale tradethe density is due to the distribution of pharmaceuticals (and other medical equipment). This show on the one hand that such mobility pattern tables are very sensitive to the industrial breakdown

7.3 Mobility rates and R&D intensities

In this seciton we will investigate the relationship between the sectoral mobility rates from the tables above with the sectoral R&D intensities.

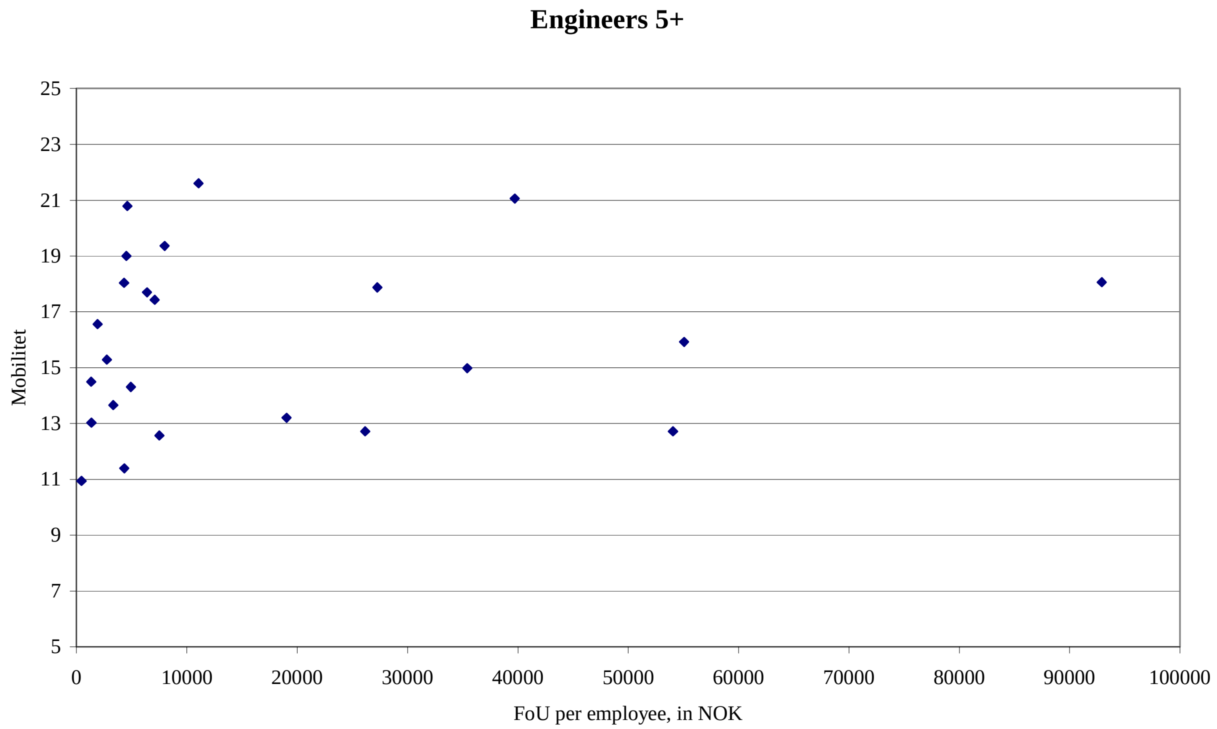
Figure 2 All employees, plot of R&D intensities and mobility rates



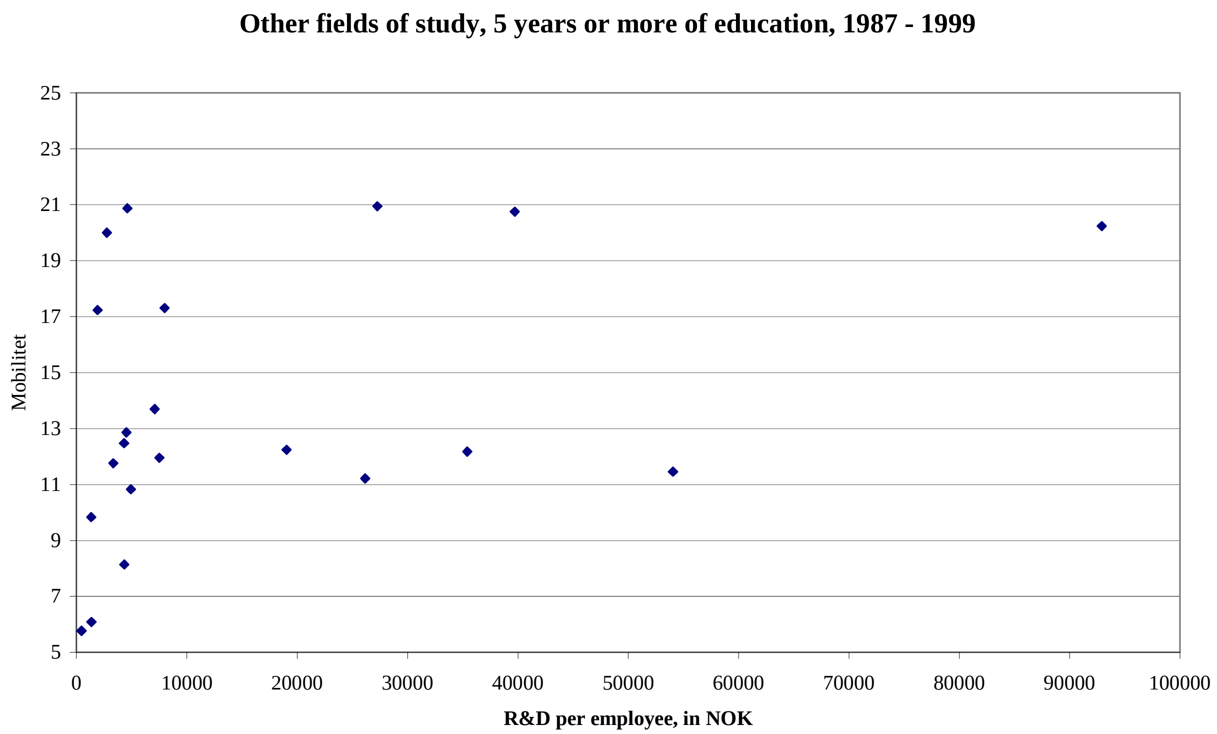
There does not seem to be any strong tendency for the R&D intense industries to have very extreme mobility. Given the noise in the R&D intensities and the mobility rates, no firm conclusions can be drawn from this. One could speculate if the tendency for rates to be either in the higher and lower than the majority of rates in the case of the R&D intensive sectors is explained by the character of the secotors.

The to most mobile and at the same time R&D intense sectors are fishfarming and biz.services&computing. Especially the computer services part of the latter is a very hectic sector with rapid technological changes, shortage of labour resulting in a very strong demand for labour so high mobility is as expected. The high mobility of fishfarming migh be more explained by structural changes (buy-ups, mergers) that have characterised this sector. Wmigh be more explained by structural changes (buy-ups, mergers) that have characterised this sector. Since the handling of such firm demographic phenomena is difficult, this high mobility might to a certain exten be a statistical artefact.

Figure 3 Enginneers 5 or more years, mobility vs. R&D plot, all years

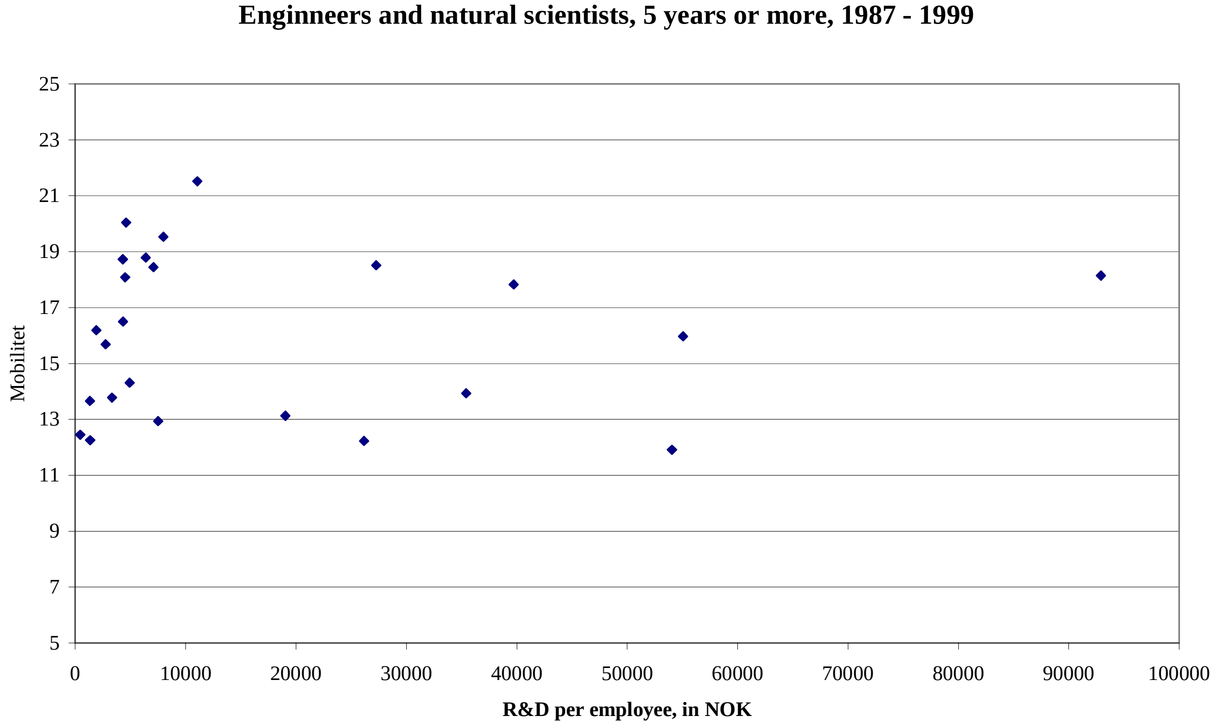


Looking at the avant-garde of innovation, the highly skilled engineers we see first of all that the mobility is increasing, the distribution moves upwards. Most of the rates are over 13% which was in the upper part when we looked at the whole population. There is still not obvious difference between the high- and low R&D intensity industries.



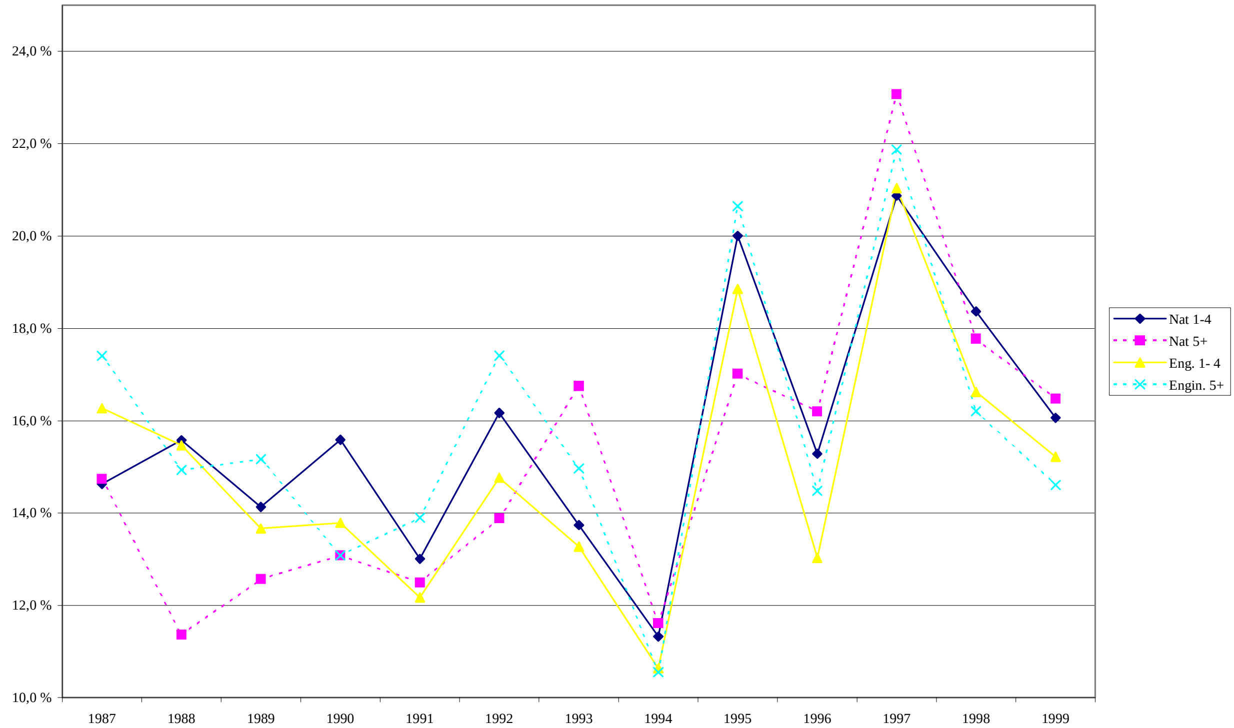
Looking at this figure one must keep in mind the very special sectoral breakdown used, but it is interesting to see that the polarisation between the low and high among the R&D branches is popping up.

Figure 4 Engineers and natural scientists, 5 years or more, 1987 - 1999



In this figure we look at the engineers and natural scientists with long educations, and the picture changes. The high R&D sectors are in the same range as the other sectors. If there is a tendency it is rather that the R&D intense are a bit lower, which might be a sign that the need for more stable teams, more knowledge accumulation and transfer is outweighing the strong demand for highly skilled in the R&D intense sectors.

7.3.1 The difference between short and long educations



We round of this section with looking at a the overall mobility rates for the four groups of thechnologists. From other studies like Graversen et al. 2001 we generally know that there are a sligth tendency for the higher educated to be a slightly more mobile when age is controlled for. Here the age is as mentioned above indirectly controlled for by setting the minimum income to 150.000 NOK per year. But there is no obvious difference between the long and short educations among the technologists. This migh be caused by deficiencies in the norwegian data connected to the problems with the firm IDs both before and especially after 1994 where the mobility rates are very, very strongly fluctuating. There is no reason to believe that this actually in any way reflects any such abrupt changes in the propability for employees in Norway to change jobs.

Chapter 8. Some conluding remarks

The aim of this paper was to make a "tour de horizon" in order to look for patterns that could give support for the general hypothesis that technologist are important for innovation, for value creation.

From the more general and theoretical discussions it flows that if the economy is on a rather stable growth path, both on a macro and a mezo/sectoral level, then the mobility rates should be within a range of 5-25% with the center of gravity in the middle of that range. And this prediction is confirmed by the data.

The next question would be if some of the different labour market mechanisms affected the technologist in a radically different manner than other groups, but the indications for that are weak.

This is not the place to repeat all the caveats reagarding the quality of the data, but it is clear that for being able to analyse the mobility patterns in greater detail, the present data are not reliable enough. Before 1995 the firm IDs are structurally deficient on the establishemnt level and the enterprise level is really a second best for analysing the mobility of persons from a competence and knowledge diffusion perspective.

The period analysed is the end of a spectacular rise in the number of highly educated in all fields of study. The consequences of this continous inflow of highly skilled into the labour marked in conjunction with a rapid technological development lead to high mobility rates in order for production technologies to change, in order to reallocate competences to utilise the ever-changing technology. And that is also one of the major findings that for highly skilled the mobility rates are centered around 15-20% job-to-job mobility which by no means can be considered to be low.

This paper has purposedly been touching upon a lot of issues, looking at rather straighforward aspects of the stocks and flows of technologists. But since this had not been done before the fact that we did not find anything spectacular is in it self not worrying..

Appendix – Fields of education ISCED 1997

0	**General Programmes**	345	Management and administration
01	Basic/broad general programmes	346	Secreterial and office work
010	Basic/broad general programmes	347	Working life
08	Literacy and numeracy	38	Law
080	Literacy and numeracy	380	Law
09	Personal skills	**4**	**Science, Mathematics and Computing**
090	Personal skills	42	Life science
1	**Education**	421	Biology and biochemistry
14	Teacher training and education science	422	Environmental science
140	Teacher training and education science (broad programmes)	44	Physical science
142	Education science	441	Physics
143	Training for pre-school teachers	442	Chemistry
144	Training for teachers at basic levels	443	Earth science
145	Training for teachers with subject specialisation	46	Mathematics and statistics
146	Training for teachers of vocational subjects	461	Mathematics
2	**Humanities and Arts**	462	Statistics
21	Arts	48	Computing
210	Arts (broad programmes)	481	Computer science
211	Fine arts	482	Computer use
212	Music and performing arts	**5**	**Engineering, Manufacturing and Construction**
213	Audio-visual techniques and media production	52	Engineering and engineering trades
214	Design	520	Engineering and engineering trades (broad programmes)
215	Craft skills	521	Mechanics and metal work
22	Humanities	522	Electricity and energy
220	Humanities (broad programmes)	523	Electronics and automation
221	Religion	524	Chemical and process
222	Foreign languages	525	Motor vehicles, ships and aircraft
223	Mother tongue	54	Manufacturing and processing
225	History and archaeology	540	Manufacturing and processing (broad programmes)
226	Philosophy and ethics	541	Food processing
3	**Social sciences, Business and Law**	542	Textiles, clothes, footwear, leather
31	Social and behaviourial science	543	Materials (wood, paper, plastic, glass)
311	Psychology	544	Mining and extraction
312	Sociology and cultural studies	58	Architecture and building
313	Political science and civies	581	Architecture and town planning
314	Economics	582	Building and civil engineering
32	Journalism and information	**6**	**Agriculture and Veterinary**
321	Journalism and reporting	62	Agriculture, forestry and fishery
322	Library, information, archive	620	Agriculture, forestry and fishery (broad programmes)
34	Business and administration	621	Crop and livestock production
340	Business and administration (broad programmes)	622	Horticulture
341	Wholesale and retail sales	623	Forestry

342	Marketing and advertising	624	Fisheries
343	Finance, banking, insurance	64	Veterinary
344	Accounting and taxation	641	Veterinary
7	**Health and Welfare**	812	Travel, tourism and leisure
72	Health	813	Sports
720	Health (broad programmes)	814	Domestic services
721	Medicine	815	Hair and beauty services
723	Nursing and caring	84	Transport services
724	Dental studies	840	Transport services
725	Medical diagnostic and treatment technology	85	Environmental protection
726	Theraphy and rehabilitation	850	Environmental protection (broad programmes)
727	Pharmacy	851	Environmental protection technology
76	Social services	852	Natural environments and wildlife
761	Child care and youth services	853	Community sanitation services
762	Social work and counselling	86	Security services
8	**Services**	860	Security services (broad programmes)
81	Personal services	861	Protection of persons and property
810	Personal services (broad programmes)	862	Occupational health and safety
811	Hotel, restaurant and catering	863	Military and defense

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STEP-gruppen ble etablert i 1991 for å forsyne beslutningstakere med forskning knyttet til alle sider ved innovasjon og teknologisk endring, med særlig vekt på forholdet mellom innovasjon, økonomisk vekst og de samfunnsmessige omgivelser. Basis for gruppens arbeid er erkjennelsen av at utviklingen innen vitenskap og teknologi er fundamental for økonomisk vekst. Det gjenstår likevel mange uløste problemer omkring hvordan prosessen med vitenskapelig og teknologisk endring forløper, og hvordan denne prosessen får samfunnsmessige og økonomiske konsekvenser. Forståelse av denne prosessen er av stor betydning for utformingen og iverksettelsen av forsknings-, teknologi- og innovasjonspolitikken. Forskningen i STEP-gruppen er derfor sentrert omkring historiske, økonomiske, sosiologiske og organisatoriske spørsmål som er relevante for de brede feltene innovasjonspolitikk og økonomisk vekst.

The STEP-group was established in 1991 to support policy-makers with research on all aspects of innovation and technological change, with particular emphasis on the relationships between innovation, economic growth and the social context. The basis of the group's work is the recognition that science, technology and innovation are fundamental to economic growth; yet there remain many unresolved problems about how the processes of scientific and technological change actually occur, and about how they have social and economic impacts. Resolving such problems is central to the formation and implementation of science, technology and innovation policy. The research of the STEP group centres on historical, economic, social and organisational issues relevant for broad fields of innovation policy and economic growth.