



Analyseinstitut for Forskning

Mobility among Researchers



Working papers 2001/7
ISSN: 1399-8897

The Danish Institute for Studies in
Research and Research Policy
Finlandsgade 4
DK-8200 Aarhus N
www.afsk.au.dk

August 2001

Mobility among Researchers

By

Kamma Langberg and Ebbe K. Graversen^{*)}

^{*)} Email: KL@afsk.au.dk and EG@afsk.au.dk. Telephone: +45 8942 2394. The Danish Institute for Studies in Research and Research Policy, Finlandsgade 4, DK-8200 Aarhus N
Acknowledgements: Financial support from The Danish Institute for Studies in Research and Research Policy is gratefully acknowledged.

Abstract

Job mobility among high-knowledge workers can be seen as a possible danger for an organisation, that loses workers because of the potential knowledge drain in the total knowledge stock of the organisation. Conversely, job mobility can also be seen as a possibility to strengthen an organisation since inflow of new workers can open access to new knowledge resources through their expert knowledge, networks or knowledge exchange in the organisation. Hence, the task for management in knowledge organisations is to keep knowledge inside the organisation even though workers may leave and to attract new workers with new knowledge, that can increase the knowledge stock inside the organisation. This is possible if the individual specific knowledge is shared during the work within the organisation in such a way that the knowledge is incorporated in other individuals in the organisation and/or in the organisation as such. In other words it is important to create a knowledge organisation that keeps the knowledge inside the organisation instead of inside the workers, i.e. externalise the individual specific knowledge but still keeping it internally inside the organisation. Such an organisation may become an attractive and innovative research organisation since it is less vulnerable against expert workers leaving the organisation.

The present paper describes one part of the infrastructure in the Danish national innovation system, namely the researcher mobility. Especially, the knowledge imbedded in researchers moving inside, into and out of the universities and public research institutes. Section 1 introduces reasons for job mobility and its importance in a knowledge management perspective. A theoretical modelling of the job mobility and innovation potentiality is set up in Section 2. A knowledge management and a growth theory perspective are given in Section 2.1 and 2.2 respectively before it is set together in Section 2.3. Finally, Section 3 presents empirical numbers on reasons for and levels of job mobility among university and R&D sector researchers in Denmark. Extensive survey information as well as register information is presented in Sections 3.1 and 3.2 respectively. The paper concludes with a linking between the theoretical and the empirical parts of the paper.

The empirical results indicate that there is a considerable job mobility of researchers in Denmark, and that this job mobility increases the knowledge in the research organisations leading to an increased national knowledge stock, which increases the overall national growth potential.

Table of Contents

1. Introduction.....	5
1.1 Job mobility incentives among publicly employed researchers	7
2. Job mobility and innovation ability in research organisations	8
2.1 Job mobility in a knowledge management perspective	8
2.1.1 Job mobility at university institutions in a knowledge management perspective ..	10
2.2 Job mobility in a growth theory perspective	11
2.3 The knowledge management and the economic growth	12
3. Job mobility at universities and governmental research institutes	13
3.1 The mobility of university researchers analysed from survey data	14
3.2 Annual job mobility rates based on the register database IDA.....	19
3.2.1 Inflow job mobility rates over time	21
3.2.2 Intra and inter sectoral job mobility rates.....	23
4. Conclusion and further perspectives	27
References	30

1. Introduction

An important part of the knowledge base in an organisation is the individual specific knowledge embodied in the employees. Job mobility among the high-knowledge workers can be seen as a possible danger for an organisation that loses workers because of the potential knowledge drain in the total knowledge stock of the organisation. Conversely, job mobility can also be seen as a possibility to strengthen an organisation since inflow of new workers can open access to new knowledge resources through their expert knowledge, networks or knowledge exchange in the organisation. Hence, the task for management in knowledge organisations is to keep knowledge inside the organisation even though workers may leave and to attract new workers with new knowledge that can increase the knowledge stock inside the organisation. This is possible if the individual specific knowledge is shared during the work within the organisation in such a way, that the knowledge is incorporated in other individuals in the organisation and/or in the organisation as such. It is in other words important to create a knowledge organisation that keeps the knowledge inside the organisation instead of inside the workers, i.e. externalise the individual specific knowledge but still keeping it internally inside the organisation. Such an organisation may become an attractive and innovative research organisation since it is less vulnerable against expert workers leaving the organisation.

Externalising the individual knowledge to organisation specific knowledge is a knowledge management issue. However, the job mobility out of the organisation spreads the knowledge to other organisations through their inflow of the mobile workers. In the medium run, the knowledge will be spread through out the entire economy increasing the national knowledge stock significantly. Romer (1986) among others argues that this knowledge diffusion is a vital contributor to the economic growth of the entire economy, especially if not only the firm have access to the knowledge in the short run. Physical mobility of high-knowledge workers has an immediate influence on the economic conditions in the country. In this set up, university institutions and research institute develops fundamental new knowledge, which may become public non-rival knowledge through job mobility and new educated candidates but also through cooperation and knowledge sharing. From an economic point of view it can also be argued that publicly financed research, due to its non-rivalness, is necessary since its social benefit for the economy is positive. Private organisations may not perform enough basic or fundamental research since the net benefit for the organisation may be negative unless the knowledge can be kept as an internal resource through for example patents or intellectual property rights. However, such restrictions on the knowledge decrease the synergy effects of the access to the knowledge for the entire economy. This implements a significant role for

publicly funded research, but also a need for an additional diffusion of the obtained research results.

Hence, knowledge embodied in employees in an organisation is important both for the organisation and for the entire economy. A continuously steady circulation and exchange of knowledge, i.e. employees, between organisations, firms or research institutes increases the knowledge stock in the organisations and increases the performance and efficiency in the work force, i.e. creates economic growth.

A way of addressing the knowledge exchange in the organisations and in the economy in a knowledge management perspective is through the use of an extended version of the *knowledge spiral* presented by Nonaka et al (1998). Seen in this perspective the knowledge stock in a firm or research organisation can be corroborated by either

- Employing persons with new knowledge (or competence), i.e. newcomers from other work places or from outside the active labour force (new educated candidates etc.). This may broadly be called job mobility.
- Educating persons already within the organisation, i.e. internal qualification increases. This kind of qualifications increases the general knowledge at the work place and is one of the most important reasons for analyses of mobility. A person moving needs time at the new work place to learn from and teach colleagues. After a while all is learned and taught, so it is optimal for the economy but not necessary for the organisation that the employee moves again.
- Circulating staff already employed between organisations, i.e. temporary mobility. This is a continuation of internal education. Here, organisations learn from each other and bring the new knowledge back to the work place. This seems to be an efficient way to increase the knowledge diffusion avoiding some of the fixed costs connected to permanent job shifts.

All three ways of optimising the knowledge base is used among research organisations, where results are shared (public and non-rival information in form of publication of the results from research projects), and where mobility is seen as a knowledge resource equal to education.

In that perspective, this present paper focus on

- Job mobility as one form of internal and external knowledge transferring between research organisations and between these and the surrounding economy
- Job mobility as an issue in the discussion of national innovation ability as well as an issue in public and private research management

1.1 Job mobility incentives among publicly employed researchers

The Danish publicly financed research system, i.e. universities and government research institutes, are characterised by the same job structure. Within the research organisations there are numbers of time-limited jobs especially targeted to younger researchers e.g. research assistants, PhD-students, Post Docs, amanuensis, researchers, or assistant professors. In Denmark these jobs are usually limited to a 2 or 3-year period, which can be extended by shifts between categories, e.g. a researcher obtaining a PhD can have another 3-year period as assistant professor if there is an open job position. There also exist time-limited jobs connected to specific research projects, typically externally financed. Those time limits often result in forced job mobility from one research institution to another, e.g. mobility is a prolonged tradition among younger researchers.

Most researchers are therefore likely to have been employed elsewhere during their career, resulting in a mobility that is not necessarily the result of a free choice. Hence, the mobility of researcher cannot always be taken as the result of the researcher optimising her lifetime income through a freely planned career but rather as a second best optimisation given the labour market conditions. Other researchers are seeking job in specific organisations in order to improve their knowledge, because some research units are better off intellectually than others in specific areas, and because job experience from some institutes are valued higher than job experience from others. Other researchers again, are moving from one place to another because they wish to change their scientific research area or simply because they dislike the present work place.

For some of the researchers the job mobility wishes are conflicting with their family life, e.g. when mobility includes movement from one geographical area to another. This is a neglected issue in many studies of researcher mobility or rather lack of researcher mobility. In Denmark both spouses are usually working, which means that not only the researcher but also the spouse needs a new (attractive) job. Combined with large fixed costs of moving the place of living, such structural matters reduce the job mobility rates among established

(older) researchers. The wage differentials in the publicly financed research institutes in Denmark are so low that the wage compensation from job shifts typically not covers the immediate fixed costs involved in the job shift.

2. Job mobility and innovation ability in research organisations

The present section links the job mobility to two theoretical positions: the knowledge management and the economic growth. The two are linked in a way such that it describes how the individual knowledge through knowledge exchange is spread to the organisation, to the sector or branch and finally to the entire economy where the increased knowledge stock increases the economic growth and national wealth.

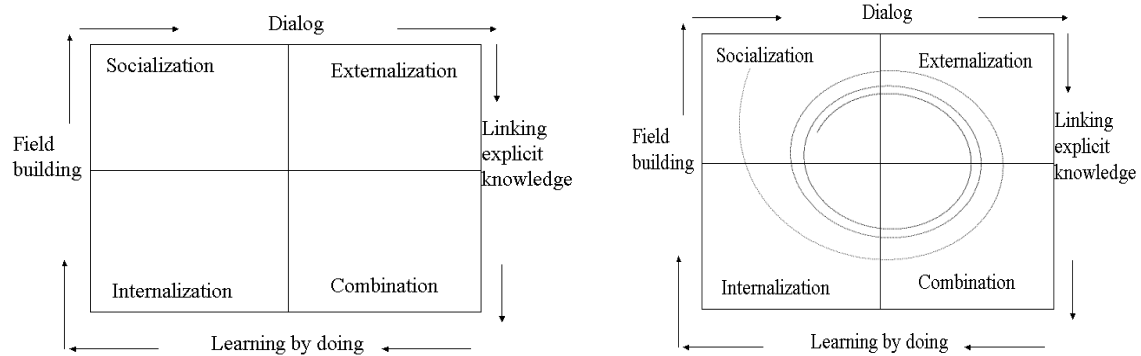
2.1 Job mobility in a knowledge management perspective

Knowledge can be regarded and analysed in different ways. Nonaka et al (1998) presents an interesting view where knowledge is divided into tacit and explicit knowledge. These two types are seen as mutually complementary entities where only the latter can be formally measured. Nonaka et al. assumes that new organizational knowledge is created by human interactions or exchange among knowledge workers with different types of tacit and explicit knowledge and that this social and epistemic interaction process brings about four nodes of knowledge transmission, namely (c.f. Figure 1)

- **Socialization:** from individual tacit knowledge to group tacit knowledge
- **Externalisation:** from tacit knowledge to explicit knowledge
- **Combination:** from separate explicit knowledge to systemic explicit knowledge
- **Internalisation:** from explicit knowledge to tacit knowledge

The four nodes can be seen as the background for the knowledge spiral, that often starts with *socialization* where the knowledge by *dialogue* converts into *externalisation*, externalisation converts by *linking with explicit knowledge* into *combination*, *learning by doing* then converts combination into *internalisation*, where *field building* converts into *socialization*. The circular transmission movement increases the knowledge stock in each tournament.

Figure 1. Nonaka et al's knowledge spiral



Source: Nonaka et al (1998) and own drawing.

In Nonaka et al's model it is assumed, that the organization can integrate external knowledge from researchers into *combination*. Explicit knowledge from the outside is used in combination with inside knowledge or the external knowledge is integrated into the organization through a process of socialization of the researcher. Hence, job mobility into an organization can add knowledge to the organization, knowledge, that can be converted into group knowledge by socialization, dialogue etc. Hence, mobility of individuals can add knowledge that is not exclusively individual, because the knowledge can be transmitted or converted into collective, organizational knowledge.

Mobility out of an organization can cause a loss of knowledge, if the individual is the only carrier of this specific knowledge not known to others. The lost knowledge may be so central and important that it for a short time paralyses the organization. However, if the knowledge is transmitted and converted systematically within the organization, the single individual will not be the only carrier of the vital knowledge and a part or all of this knowledge will remain in the organization even if the individual leaves with his knowledge intact. This is so since knowledge in opposition to other inputs in production is a non-rival good, e.g. several individuals can use it simultaneously.

If knowledge is systematically formalized and kept inside the organisation then individual mobility out of an organization might be neutral for the knowledge stock and it might even add knowledge to the organization through replacement of an individual knowledge worker with another.

2.1.1 Job mobility at university institutions in a knowledge management perspective

University institutions and other public research institutes can generally be viewed as knowledge production and knowledge transmission units, i.e. net suppliers of knowledge to the community. Publications, patents, projects etc. are often used to measure the knowledge production from a research institute but this is only a part of the explicit knowledge production these places.

Universities are also producers of tacit knowledge. This tacit knowledge is often thought of as individual specific tacit knowledge, but the research organisations generates new knowledge that is transmitted and converted into tacit knowledge in the organisation as a consequence of their organizational structure. The knowledge is not only spread among the employees, but also to students, PhDs, guest researchers and others like private firms etc. cooperating with the research institutes. The students, guest researchers and other mobile individuals afterwards transmit the institute specific tacit knowledge into other organisations. Hence, high-knowledge individuals will not only have an explicit observable knowledge like their degree but also a tacit knowledge depending on the education and university choice and their work, research and innovation experience.

When managing the knowledge of researchers at the university institutions, it is important to realise that some of the work time used internal in the institutions on knowledge exchange e.g. discussions of working papers and ideas at seminars, work shops or conferences, or even informal discussions around the coffee table, are important and classic ways to transmit tacit knowledge within research organisations, and that this form of transmitting knowledge is essential to the knowledge production these places. In other less knowledge oriented organisations such use of work time would probably be characterised as useless waste of time.

It is also a core issue to the research management to support mobility among the researchers and to ensure that the mobile individuals carry new knowledge into the organization. In a broader sense this also means that they carry knowledge out of the organisation since mobility diffuses knowledge rather than only collecting knowledge. There is a long tradition for short term visiting fellowship across research organisations in the academic world. Hence, the mobility and exchange of knowledge already exists but is important to stress that this is an academic phenomena due to the non-rival knowledge innovated in these organisations. Knowledge protection would probably hinder or at best reduce the knowledge exchange in the private research organisations. In order to increase the community knowledge

level and its diffusion speed, this justifies a role for the publicly financed research organisations, i.e. the universities etc.

2.2 Job mobility in a growth theory perspective

The newer growth theory has for long claimed that knowledge and knowledge creation are a vital force in the growth and development of countries and regions. The original growth model operates with capital and labour as the sole input factors, c.f. Solow (1957), without specifying whether the capital is physical capital solely or both physical and intellectual. The capital and labour input are not able to explain the empirical growth rates observed since. So the non-explained residual, which has been called the total factor productivity, TFP, has been used to augment these input to reach the actual observed growth levels. The TFP or 'black box' has ever since been explored and the explanations are among others that the TFP reveals technical progress, knowledge levels, and innovation abilities. As a proxy for all these, the knowledge level among the workers and organisations are a good approximation. Hence, the knowledge accumulation, creation and diffusion are important for the economic growth.

The endogenous growth models developed in the 1980s and 1990s have all in many ways tried to decompose and explain the TFP part of the economic growth in a consistent and dynamic way.¹ Romer (1986, 1990) and Lundvall (1992) among others argue that growth especially depends on the knowledge infrastructures in the economy. Romer (1986) argues that increasing knowledge imbedded in humans, i.e. human capital, increases the production efficiency and that the consequential learning increases the knowledge accumulation in the economy. Romer (1990) further develops these arguments in a policy recommendation that investment in knowledge is a deliberate decision for the organisations in order to improve their productivity. Especially the publicly provided knowledge, e.g. the universities, is a non-rival good that can improve productivity in the entire economy, but the knowledge has to be spread in the economy in an efficient way. Lundvall (1992) argues that the channels in which the knowledge is spread are as important as the knowledge creation itself. This leads to the knowledge management perspective that claims the importance of networks, institutional structures, and new candidates as knowledge carriers that diffuses the newest research knowledge.

¹ Usually the empirical outcome is a model, which in practice although not theoretically is a knowledge-augmented version of the original Solow model.

In the community perspective the diffusion of the newest knowledge to all parts of the economy in an efficient way secures that they can handle it and become innovatively up to date. This also means that a country or a firm/university can lose growth if some research areas are totally abandoned, since nobody in this case can use innovation results from other sources, c.f. Salter and Martin (1999). This part of the growth theory is called creative destruction, where new innovations are necessary because old innovations become continuously outdated by the new.

The universities are usually publicly owned and financed. The knowledge and innovation created here shall be valued according to their influence in the entire economy. This is usually far above the corresponding private value, c.f. Salter and Martin (1999). Hence, there are strong arguments for a public research sector that primarily does basic research, which in the short run becomes uninteresting (with a negative return) for the private firms. Salter and Martin also find that there are geographical effects, so firms situated near research institutes or universities have large benefits from this, and that one of the most important channels for knowledge diffusion is through candidates from universities. They also find that the most efficient knowledge diffusion through candidates comes from research institutes where there are both research and teaching of students.

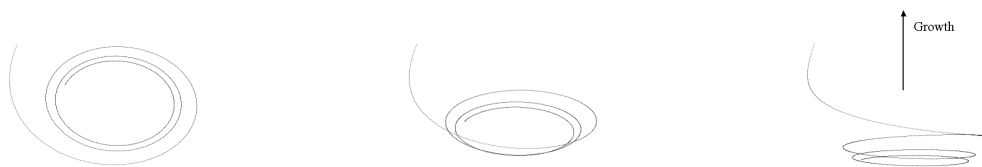
From a community point of view, an effective circulation of the publicly provided knowledge is important for the economic growth in the economy. Hence, an efficient knowledge infrastructure at the universities and governmental research institutes are of vital importance. Besides the knowledge diffusion through written materials, lectures, cooperation and candidate production to the surrounding economy, the research institutes themselves also need to be efficient. This can be obtained through networks, contacts and cooperation but physical mobility is another way. A considerable mobility of researchers between research jobs is preferable to diffuse and recollect new knowledge. However, a too high mobility is not preferable since it takes time to exchange and obtain new knowledge in the organisations as Nonaka et al's (1998) knowledge spiral demonstrates. Hence, the community return from job mobility among researchers could be a bell shaped function of the mobility rates, where medium rate job mobility maximises the community pay-off.

2.3 The knowledge management and the economic growth

Linking the knowledge diffusion aspect of Nonaka et al (1998) with the economic growth aspect of Romer (1990) gives a theoretical linkage of the way knowledge transmit into welfare. The dynamic version is a never-ending circular model where knowledge creates

economic growth that creates resources that is invested in new knowledge that creates new growth etc. At the same time the knowledge stock and the innovation capability increases at the individual, organisation and community level. Figure 2 schedules the three dimension modelling where the dynamic exchange of tacit and explicit knowledge are linked to the economic growth. The model shows the movement and transmission of just one knowledge unit. In reality a continuum of knowledge units moves around in the system, creating basis for continuous positive growth. Somewhere on the development line the knowledge may become outdated, dropping the line to zero growth, or become flat, giving a steady contribution to growth. However, no matter what new knowledge eventually takes over maintaining a positive economic growth.

Figure 2. The knowledge spiral and the linkage to economic growth



3. Job mobility at universities and governmental research institutes

This present section gives empirical evidence for the job mobility of publicly employed researchers measured in various ways. In a knowledge diffusion aspect, job mobility is not only a shift of job category or work place, but also whether employed researchers are educated internally, recruited from other research environments, have been temporarily or permanent away, or whether a researcher is highly cooperating with researchers etc. from other research organisations. However, a commonly used measure is still the simple work place mobility, which is also used to measure the diffusion of knowledge from the knowledge producing sectors, e.g. universities etc., to the knowledge using sectors, which are all others. Section 3 gives empirical figures on these mobility rates inside, into and out of the Danish research sectors and on the overall job mobility rates in Denmark.

3.1 The mobility of university researchers analysed from survey data²

This subsection starts with a general description of the mobility of university researchers. First, mobility in the work career between different work places; second, mobility as a shift between education place for the candidate and the PhD degree and third, mobility as a shift of main scientific fields for the candidate and the PhD degree, c.f. Box 1 below. These mobility measures indicate whether the employed researchers are circulating between research organisations collecting knowledge at different levels and places across universities and fields. In the last part of this section, the researchers' attitude towards some job related statements on research management are analysed.

BOX 1: Definitions of mobility terms used in Section 3.1.

All mobility rates in Section 3.1 is inflow rates, e.g. flow into a university researcher job

- 1. Mobility between work places** is defined as at least 1-years of employment at another place than the university institute, where the researcher is presently employed.
- 2. Mobility between education places** is defined as a shift between the university, where the researcher took the candidate degree (MA, MSc. etc.) and the university where the researcher took the PhD-degree /doctoral degree.
- 3. Mobility between scientific fields** during the education is defined as a shift between

In Denmark the majority of the university researchers are employed with contracts including both research and teaching. The usual job structure includes time-limited assistant researcher, researcher, and assistant professor jobs and permanent jobs as associate professor or full professorship. Only a minority are employed with contracts connected to research solely, or to a specific research project.³ The 100 percent research jobs are all time limited. Hence, mobility rate, age and actual employment situation are closely connected.

A little less than 30 percent of the Danish university researchers are women and they are on average younger than their male colleagues. The gender difference is largest among the associate professors and full professors. Hence, there exists a historically dependent gender inequality at the universities. There is a slow but steady increase in the proportion of female

² The analysis is based on a web-based survey conducted in December 2000 – February 2001 by The Danish Institute for Studies in Research and Research Policy.

³ The few that only have contracts as teachers are not considered as university researchers in this paper, and they are not included in the figures below.

researchers at the Danish research institutes. However, the gender differences in some scientific fields like mathematics and physics are still large.

It is commonly assumed that men and women have different mobility rates but in the case of Danish university researchers such a difference could not be found when the difference in age and employment category is controlled for.

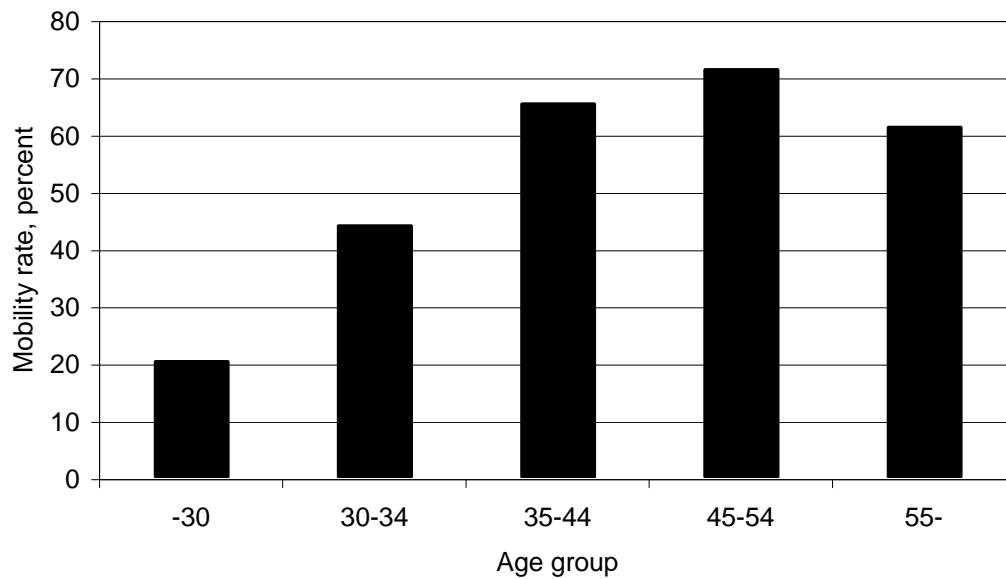
Table 3.1.1: The percentage of university researchers with work place mobility during their career (more than one years of job experience from another work place). Percent.

Employment at another work place (at least one year)	Born after 1965	Born 1965 or before
Another university in Denmark	7	26
Governmental Research Institute, GRI, in Denmark	2	8
University outside Denmark	8	21
Research Institute outside Denmark	3	10
Ministry in Denmark	2	4
EU-institution	0	1
Private company	10	15
Work experience from other work place than the present. Work place mobility rate	32	65

The job situation in the Danish academic labour market has changed considerably during the last two decades. In the beginning of the 1980's there were a high general unemployment and very few job openings at the universities. In combination with the requirement that a PhD-degree or equate became a necessary qualification for the acquirement of a job as assistant professor, it was difficult for new researchers to join the university crowd. Therefore, a part of the mobility rate among these groups are caused by academics that wanted a career as researchers and therefore had to be more mobile and flexible than usual in order to get a job as researcher. Similarly, the upstart of several new universities in Denmark created an unnaturally high amount of employees educated at another university than the one employing them. This peculiarity will eventually disappear.

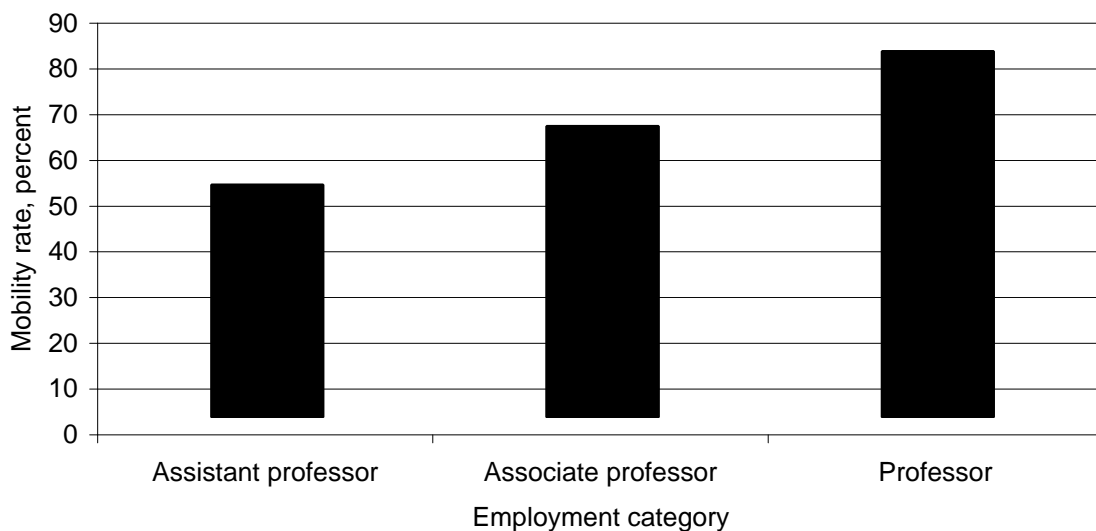
As Figure 3.1.1 shows, the workplace mobility is increasing by age although the oldest cohort (group 5) are less mobile than the next oldest cohort. In part, this can be explained by the fact that the next oldest cohort was the cohort experiencing a difficult labour market in the early 1980's.

Figure 3.1.1: Work place mobility rate by age group. Percent.



Professors as well as associate professors are generally older and more likely to have been work place mobile since their career usually are longer giving more time for job shifts between work places. It takes some years to reach the position of associate professor or full professor, and it usually includes level changes in the job structure at the universities. These level changes may also include shift of work place, i.e. change of university. As Figure 3.1.2 shows the work place mobility is strongly connected to the job position, i.e. the career length.

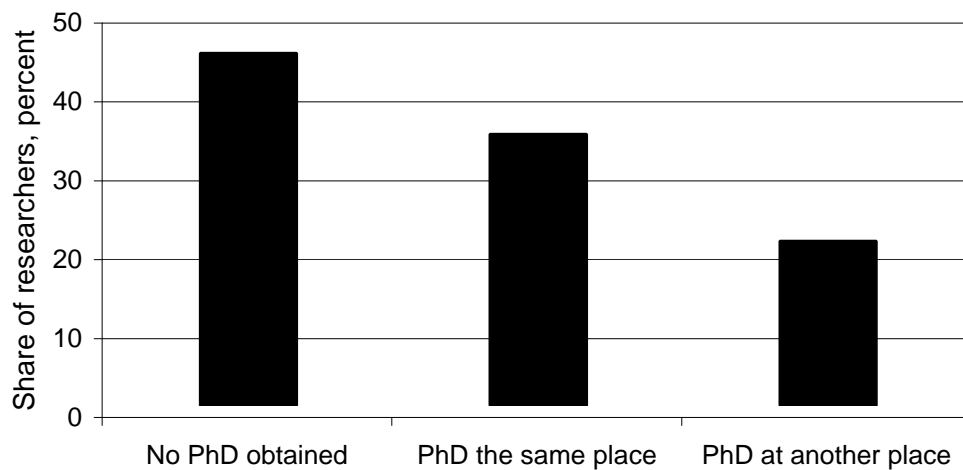
Figure 3.1.2: Work place mobility rate by employment category. Percent.



A significant share of the researchers changes university when they begin their PhD-study. Such a shift can be regarded as a form of knowledge environment mobility between two research organisations. This mobility can very well be as important to the single individual as to the organisation seen in a knowledge management perspective.

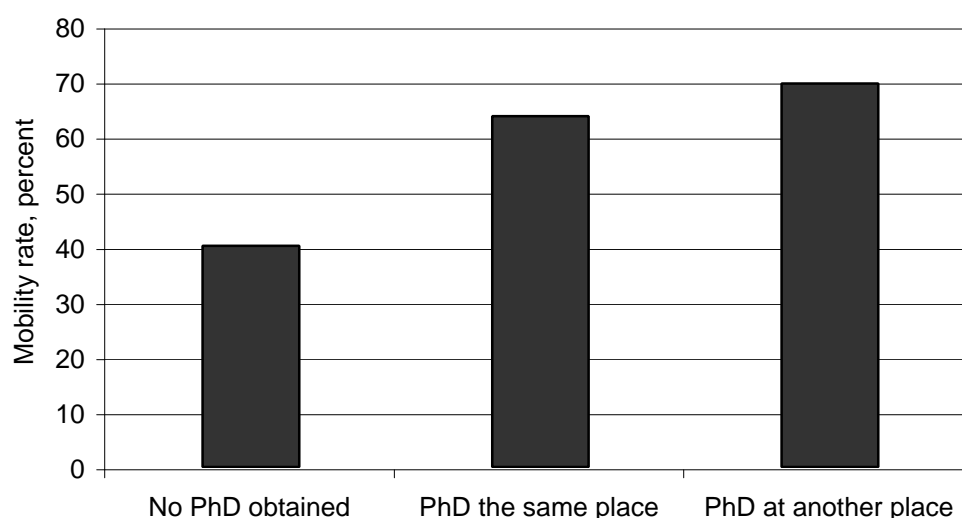
Figure 3.1.3 shows 56% of the researchers employed at Danish universities have a PhD- or doctor-degree. It is so even though that there were no tradition at Danish Universities that researchers were aiming for a PhD, before 1985, i.e. there is age dependence, such that the share of researchers with a PhD first increases and then decreases with age. Education place mobility rates can therefore only be found for those 56%. Out of the researchers who have a PhD- or doctor degree only 38% took the PhD at another university than where they graduated.

Figure 3.1.3: Education place mobility. Place of graduate education and place obtaining the PhD- or doctor-degree. Share in percent.



Mobility according to work place is correlated with mobility according to education place e.g. individuals without a PhD- or doctor degree are less work place mobile, and the individuals having a PhD- or doctor degree from another university tend to be more work place mobile as shown in Figure 3.1.4. The difference in work place mobility rates is almost equal in the different age groups no matter if a PhD degree is present or not.

Figure 3.1.4: Work place mobility among education place mobile researchers. Percent.



The scientific fields mobility is measured by a shift in scientific fields between the graduate education and the PhD-study or doctor degree. Conditional on having a PhD, 21% of these researchers have changed scientific field. Calculated for all researchers, the rate is lower, but a part of the mobility can be explained by changes in area during the PhD-study. Table 3.1.2 shows the mobility rates for the six main scientific fields used to calculate the mobility rates. The agricultural and veterinary science has the largest scientific fields mobility, compared with the graduate education field.

Table 3.1.2: Scientific fields mobility by field graduation. Percent.

Scientific area, primary education (MA, MSc etc.)	No PhD- or Doctor degree	Same scientific area	Different scientific area
Natural science	42	50	8
Technical science	45	46	9
Medical science	47	49	4
Agricultural and veterinary science	41	43	16
Social science	56	43	1
Humanities	50	46	4

There are no simple correlation between the work place mobility and the scientific fields mobility. However, there is a connection between education place mobility and scientific fields mobility. Of the PhDs who had changed education place, 49% had also changed

scientific field. The main explanation is that a few of the Danish universities are very specialized opposed the large majority covering all scientific fields.

From a knowledge management approach it could be expected that the mobility of the researcher have an impact on the attitudes toward cooperation and research management. As Table 3.1.3 shows this is in fact the case. The work place mobile researchers seems to be more collaborative on all levels wishing internal as well as external collaboration with other research organisations, private as well as public. They also find it natural to diffuse knowledge by teaching students and they find a need for a stronger visible research management at the Danish universities. Hence, the work place mobile researchers deviate significantly in attitudes compared with the less work place mobile researchers.

Table 3.1.3: Work place mobile researchers' attitude towards job related statements⁴.

Statement with a five points Likert response scale (From fully agree to fully disagree)	Work place mobile researchers
There is a need for further internal collaboration at the institute	Agree more often
I have to spend too much time on teaching	Disagree more often
It is scientific inspiring to collaborate with researchers from outside the university sector e.g. researchers from governmental research institutes or the private sector	Agree more often
There is a need for initiatives within research policy on corporation between the university and the private sector	Agree more often
There is a need for more research management at the universities	Agree more often

3.2 Annual job mobility rates based on the register database IDA⁵

The use of register data in studies of knowledge diffusion has pros as well as cons compared to survey data. The register used in the present study includes everybody employed at the establishments. This means that there is no sample errors and that the employees can be followed over time, i.e. the database is longitudinal. Unfortunately, the registers only have previously selected objective variables collected for other purposes such as tax and income registration. Furthermore, there are no emotional variables at all in the registers and more specialised information such as titles, which may be of importance at universities etc, are not

⁴ The connections are testes in log-linear models using 5-ppercent significant levels.

⁵ IDA is the Danish short term for the 'Integrated Database for Labour Market research'. IDA is created by a merge of existing national registers and covers in principal the last 25 years. The database is longitudinal in its construction and has unique links between employees and employers/establishments over time through a November registration each year.

immediately available. Another speciality in registers is the period of coverage, usually one year. Hence, the information on job mobility and job sector are measured once a year, usually in the first week of November each year. This also means that the observed job mobility rates are biased downwards since they only counts employees once even though the individuals may move job more than once a year.

The job mobility rate using the registers is defined according to Box 2 in the present section. Due to the information in the data, the definition is not equal to the mobility definitions used in the previous subsection. Box 2 explains in detail the differences in the mobility terms used below.

Section 3.2 is divided into two parts. The first gives the levels and differences in the inflow mobility rates to public research sectors in Denmark in the 1990s. The second part quantifies the flows into and out of these sectors in one specific year, 1995.

Box 2: Definitions of job mobility terms used in Section 3.2.

1. Inflow mobility

- **Job-to-job** mobility is defined as a shift of workplace between the previous year and the present, i.e. shift between two jobs, MOVERS.
- **Overall** job mobility is defined as MOVERS and new movements into job from the no-job state, ALL MOVERS = MOVERS + NEWS.

2. Inflow mobility rate

- The **job-to-job** inflow mobility rate is defined as the number of employed movers between two consecutive years divided with the total number of employees who are employed both years, $\text{MOVERS} / (\text{MOVERS} + \text{STAYERS})$.
- The **overall** inflow mobility rate is defined as the number of employees not having the same job the previous year divided with the total number of employees this year, $\text{ALL MOVERS} / (\text{ALL MOVERS} + \text{STAYERS})$

3. Inflow versus outflow mobility

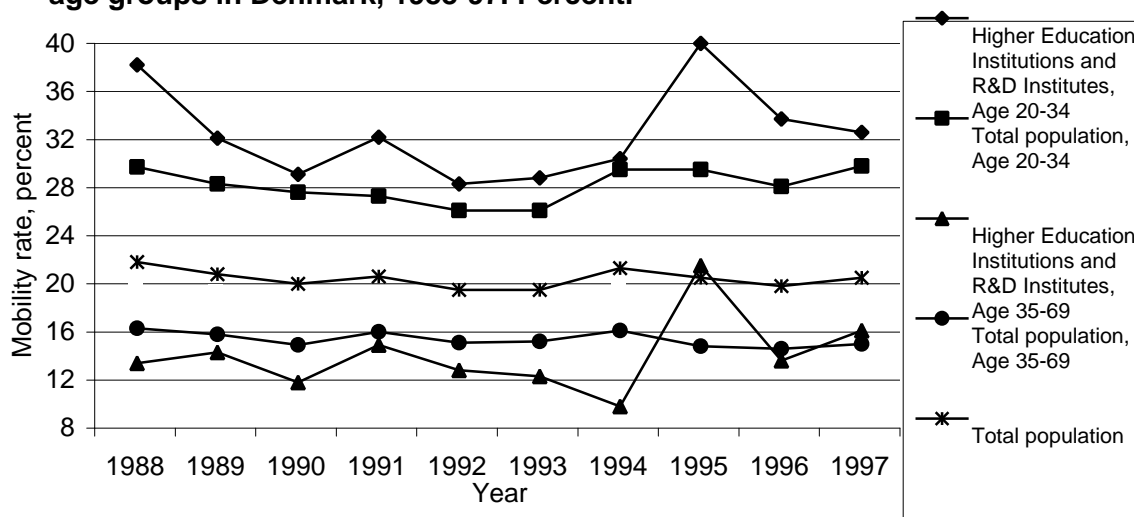
- The outflow mobility is measured as a shift of job between the present and the next year contrary to the inflow between the previous and the present year.

3.2.1 Inflow job mobility rates over time

The inflow job mobility rates over time are remarkably stable as Figures 3.2.1 and 3.2.2 shows. The figures show that the inflow job mobility rates are relatively stable over time, and less stable for the youngsters who are more influenced by business cycle effects than others, i.e. the amount of new job openings. The figures also show that young employees in general have a higher mobility than older employees and that the overall inflow mobility rate is higher than the job-to-job mobility rates. Although this is an expected result, the difference is especially large in the case of young employees. This indicates that there is a large group of new not previously employed young employees floating into the research sectors. Lastly, the figures also show that the inflow mobility rate to the research sector is above average among the young employees and that it is lower than average among the older employees. This reflects the cases of permanent job positions for associate professors and professors compared to the temporary job positions for assistant professors and PhDs among others.

The peaks in the mobility rates in 1988, 1991 and especially 1995 among the HEI and R&D employees reflect mainly reorganisations in the sector. Although the mobility rates in general are corrected for artificial mobility, they are not corrected for reorganisations where the research institutes similarly are merged, physically moved long distances and/or reequipped.

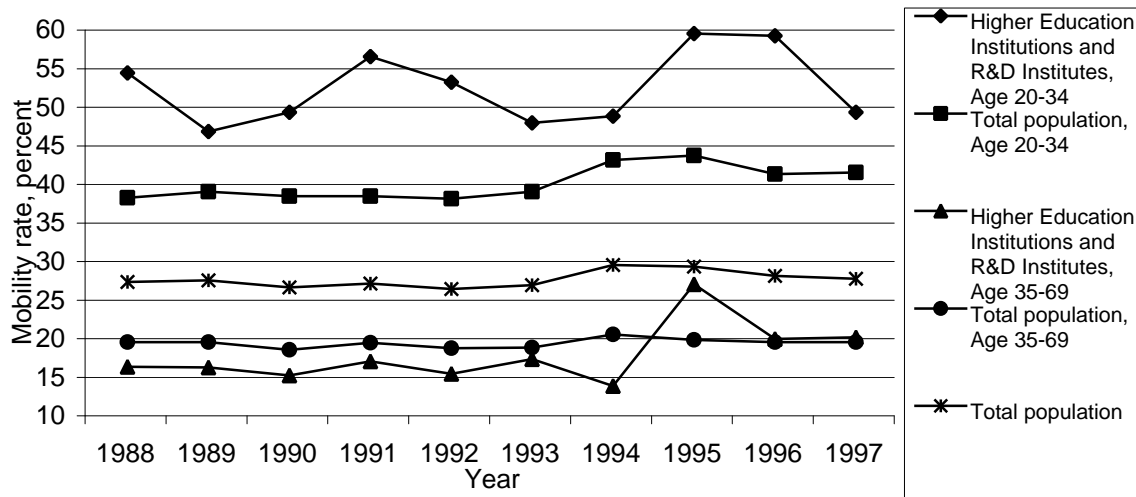
Figure 3.2.1: Job-to-job inflow mobility rates to the research sectors and all sectors by age groups in Denmark, 1988-97. Percent.



The larger job mobility rate among the young researchers is not conflicting with the lower work place mobility rate found for this group in Section 3.1. It is simply two different measures. The work place mobility rate in Section 3.1 measured shift between work places during the researchers entire work career. Older researchers have had longer time to shift between jobs, so they have a higher rate. The job mobility rate measures job shifts between two

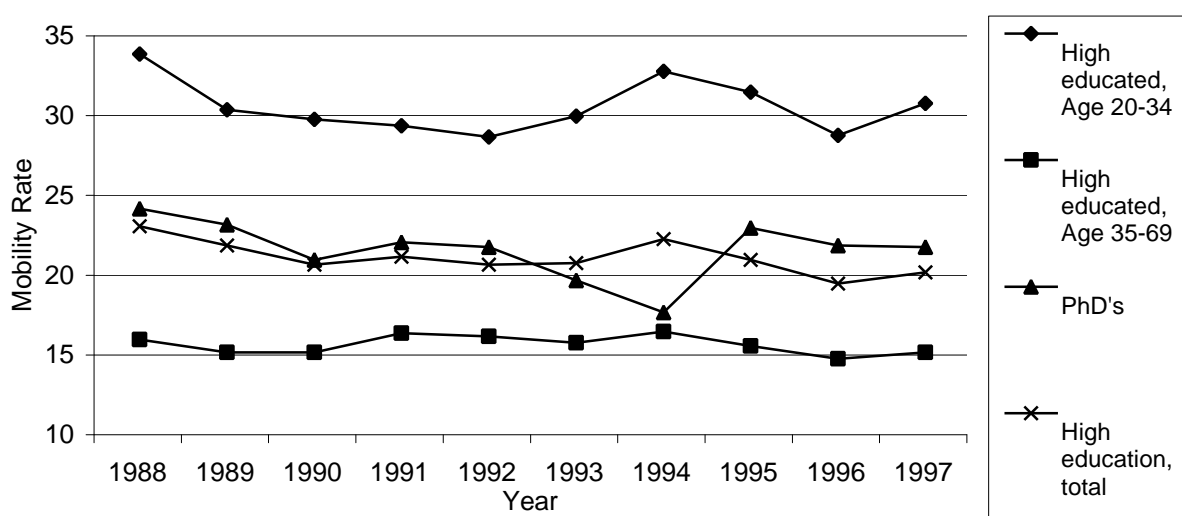
consecutive years. Being young having temporary jobs increase the probability for a job shift, i.e. job mobility, especially compared to older researchers having permanent job positions.

Figure 3.2.2: Overall inflow mobility rates to the research sectors and all sectors by age groups in Denmark, 1988-97. Percent.



That age influences the job mobility rate is not a special case concerning the job creation in the research sectors. As Figure 3.2.3 shows, the inflow job mobility rate for all high-educated young employees are considerably higher than the corresponding rate for all high-educated older employees.

Figure 3.2.3: Job-to-job inflow mobility rates to all sectors by educational level in Denmark, 1988-97. Percent.



Note: The PhDs are on average becoming younger in the period due to a large increase in the number of new PhDs after a change in 1985 and a reform in 1993, Only PhD-degrees registered in the Danish system are included e.g. not all with a PhD-degree are included in the group of PhDs.

Theoretically the findings on the age effects are very well in line with for example search theory or match theory that predicts a significant cohort difference in job mobility rates. Hence, the cohort or age differences in job mobility rates are an important aspect that has to be taken into consideration when job mobility rates are used in the knowledge management perspective and when rates are compared across sectors or groups. In another study by Graversen (2000), it is shown that job mobility increase by educational level, but less significant than the observed decrease by age.

3.2.2 Intra and inter sectoral job mobility rates

Since a high job mobility rate in itself do not reveal how broad the imbedded knowledge is spread in the community a closer look on the sectoral flows have to be included in the analysis. Internal mobility inside the research sectors have to be compared to the mobility rates between the knowledge producing research sectors and the knowledge using other sectors. Significant intra sector mobility is necessary if the knowledge has to be spread in the entire economy enabling it to handle new innovations on all levels. However, a share of the job mobile employees also needs to be inter sectoral, in order to integrate and diffuse the newest knowledge in the research sectors too.

The job mobility rates reveals that the diffusion of knowledge through employee mobility is only partly internalised in the research sectors. An internal job mobility rate in the area of 25 percent is not high and indicates significant knowledge diffusion to the knowledge using sectors. As Table 3.2.1 show the internal job mobility is less for the R&D institutes than for the higher education institutions.

Table 3.2.1: Overall inflow and outflow mobility of high-educated employees in Denmark by delivering and receiving sectors in 1995. (Shares and persons. Mobility shares sum horizontally to 100 percent)

	R&D institutes	Higher education institutions	Private production sectors ¹⁾	Services with respect to products ²⁾	Services with respect to humans ³⁾	Without job in national labour market	Number of persons moving	Number of persons employed	Average mobility rate into or out of present job
Receiving sector	Delivering sector								Into
	-----Share of mobility, pct. -----						Obs.	Obs.	Pct.
R&D institutes	16	18	4	10	19	32	729	3,420	21
Higher education institutions	5	26	2	7	25	36	4,475	12,886	35
Delivering sector	Receiving sector								Out of
	-----Share of mobility, pct. -----						Obs.	Obs.	Pct.
R&D institutes	13	23	4	23	18	20	907	3,505	26
Higher education institutions	4	30	5	2	24	27	3,874	14,524	27

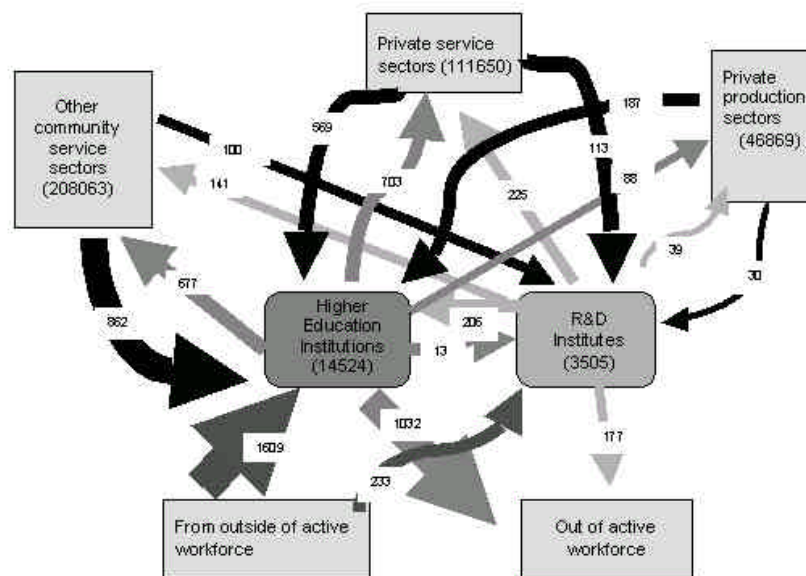
Note: ¹⁾ Agriculture, mining, manufacturing, utilities and construction. ²⁾ Trade, hotels, restaurants, transport, communications, financial intermediation and other services related to products. ³⁾ Private and public health activities, public administration and other community and private services related to individuals.

The cross deliverance between the two research sectors goes primarily from the R&D institutes to the HEIs although the absolute numbers are more equal. This can partly be explained by the size of the R&D sector being approximately 25 percent of the HEI sector when measured in employees.

Another interesting feature is the large share, around one-third, that leaves or comes into job from outside the active labour market. These employees simply disappear or pop up in the registers over employees. Among the reasons for researchers to leave the research sectors are retirement, unemployment, and leave etc. among others but a significant fraction of the researchers emigrates for shorter or longer periods to research jobs in other countries, i.e. other research environments. The latter group actually increase the knowledge economy making it global, which in a knowledge management perspective just complicates the knowledge handling by introduction of an extra dimension. Among the reasons for researchers to come into the research sectors from the 'no-job in Denmark' situation are new-educated graduates, immigrants or return migrants, and end of leaves etc.

In general 20 percent of the employees leave the research sectors each year and a similar share of the employees are newcomers in the research sectors each year. A flow diagram illustrating this pattern is given as Figure 3.2.4. The diagram is another way to illustrate the knowledge diffusion in the economy. It reveals the main flow channels although it does not show how and when the knowledge is transmitted. However, it illustrates that knowledge management is important since a large fraction of the employees, with their tacit and explicit knowledge, moves between work places or organisations between two consecutive years.

Figure 3.2.4: Overall mobility of all high-educated employees into and out of the research sectors by delivering and receiving sectors, absolute numbers, 1995.



Note: "Private service sectors" are trade, transport, finance, business and other product related services, while the private production sectors are primary sectors, manufacturing, utilities and construction.

A way to quantify the diffusion of knowledge from the research sectors is to define a comparable and calculable measure that can be used as an indicator for the diffusion. The indicator must be able to determine whether the flows of employees from the research sectors are large or significant. The chosen indicator quantifies the number of sectors that receive a large share of the mobile employees from the research sectors. It is calculated using the inverted Herfindahl index, which measure the significant or large sectors receiving employees from the other sectors.⁶ The measure depends on several assumptions. Here, 42 sectors are chosen, among these the three research sectors shown in Figure 3.2.5. Among

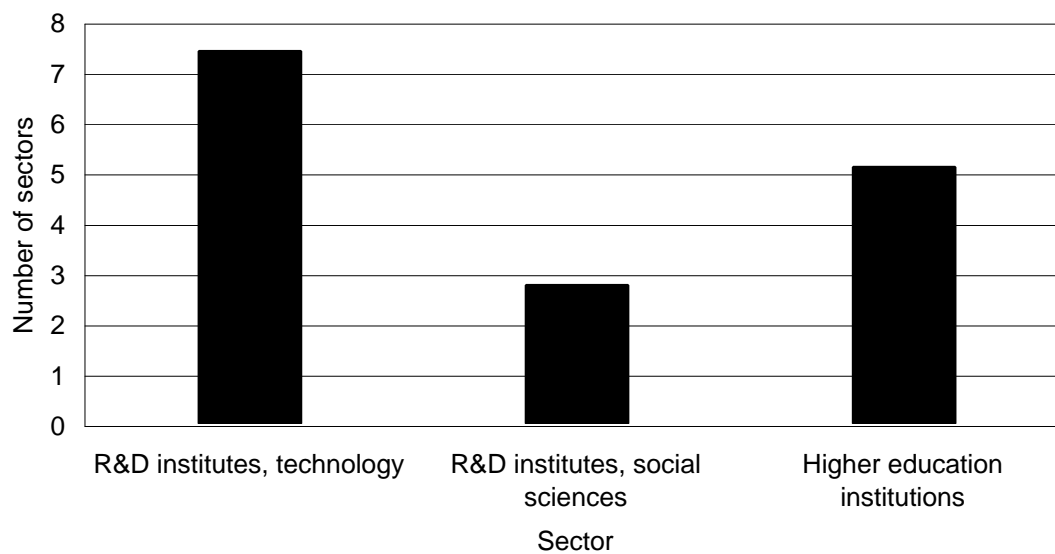
⁶ The **inverse Herfindahl index** = $[\sum_j s_{ij}^2]^{-1}$, where s_{ij} equals the share of total sum in sector i for sector j , i.e. A_{ij}/A_{ji} . The Herfindahl index is a variance measure and the inverse of it can be interpreted as the average number of effective or significant receiving sectors. With 42 sectors the minimum value is 1 and the maximum value is 42.

the 42 sectors a large fraction is in the manufacturing, i.e. production, sector, which should be a high intensive knowledge user in order to survive foreign competition.

The indicator is small if the employees in the sector all move to one other sector. If the mobility is broad and diffused, the indicator increases. In the calculations referred in Figure 3.2.5, 42 sectors have been used so the maximum number, which the indicator can take, is 42. If so, knowledge is equally diffused to all sectors which would be highly unexpected. As Figure 3.2.5 reveals, the research sectors in Denmark delivers a significant amount of employees to approximately five out of 42 other sectors. The Technological R&D institutes diffuse knowledge to most sectors, the social sciences R&D institutes to fewest sectors and the university sector in between.

The results have to be interpreted with caution. None of the three sectors have significant lower job mobility rates than the others, so the knowledge circulation is equal. The social sciences R&D institutes sector delivers to fewer sectors, but one of them is the large public sector, which is not split in small segments like the manufacturing sector. Hence, the higher indicator value for the technology R&D institute sector is partly determined by the fact that it has more 'natural' knowledge using sectors to deliver to. Another choice of sectors instead of the 42 chosen will give other values for the indicator.

Figure 3.2.5: The number of effective receiving sectors out of 42 different sectors for the research sectors in Denmark in 1996.



4. Conclusion and further perspectives

The knowledge base in an organisation imbedded in individual specific knowledge among the employees is an important resource for economic growth. Job mobility among the high-knowledge workers can drain as well as improve the total knowledge stock of the organisation. The task for knowledge management in an organisation is to keep knowledge inside the organisation even though workers may leave and to attract new workers with new knowledge that can increase the knowledge stock inside. This is possible if the individual specific knowledge is shared during the work within the organisation in such a way that the knowledge is incorporated in other individuals in the organisation and/or in the organisation as such. Nonaka et al (1998) sets up four nodes that explain the knowledge transmission in an organisation and pinpoints the necessary steps for the knowledge manager. The knowledge spiral model starts with *socialization* where the knowledge by *dialogue* converts into *externalisation*, externalisation converts by *linking with explicit knowledge* into *combination*, *learning by doing* then converts combination into *internalisation*, where *field building* converts into *socialization*. The circular transmission movement increases the knowledge stock in each tournament.

In Nonaka et al's model it is assumed, that the organization can integrate external knowledge from researchers into *combination*, explicit knowledge from the outside is used in combination with inside knowledge or the external knowledge is integrated into the organization through a process of socialization of the researcher. Hence, job mobility into an organization can add knowledge to the organization, knowledge, that can be converted into group

knowledge by socialization, dialogue etc. Mobility of individuals can add knowledge that is not exclusively individual, because the knowledge can be transmitted or converted into collective, organizational knowledge.

The job mobility out of the organisation spreads the knowledge to other organisation through their inflow of the mobile workers. In the medium run, the knowledge will be spread throughout to the entire economy increasing the national knowledge stock and consequently the economic. In this set up, university institutions and research institutes develops fundamental new knowledge, which may become public non-rival knowledge through job mobility and new educated candidates but also through cooperation and knowledge sharing.

Linking the knowledge diffusion aspect of Nonaka et al (1998) with the economic growth aspect of Romer (1990) gives a theoretical linkage of the way knowledge transmit into welfare. The dynamic version is a never-ending circular model where knowledge creates economic growth that creates resources that is invested in new knowledge that creates new growth etc.

Empirical figures from a university employee survey and a national register database confirm that mobility of workers is a way in which knowledge imbedded in employees is circulated in the economy. Focusing on the university sector researchers reveals that the majority of the researchers had been working at other work places during their work career. Similar, the survey reveals that the professors more often have worked elsewhere. This work place mobility rate is not increasing linearly in age, but peaking for the mid aged researchers. This is partly explained by labour market difficulties in the early 1980s. The survey also reveals that especially researchers educated at the specialised universities have taken PhDs at other universities and that those researchers having their PhD from another university have been more work place mobile. The mobile researchers have also a more open attitude to knowledge management at the research organisations preferring more collaboration, diffusion and cooperation internally, across institutes and across sectors.

The register data reveals stable high annual job mobility into the research sectors in the 1990s. The young researchers have the highest inflow rates into research jobs. Contrarily, the older researchers have low inflow rates, even lower than the population average job mobility rates into all sectors. The register data also reveals that the knowledge producing research sectors diffuses knowledge to all the other knowledge using sectors and that the flow of employees goes in both in and out of the research sectors. A considerable share of the mobile researchers leaves or comes into the Danish labour market each year. Some of

them migrate having research jobs in other countries, which globalise the knowledge management discussion.

The empirical findings all indicate that the knowledge imbedded in human mobility is a vital contributor to the knowledge diffusion in the economy. Taken the knowledge spiral as the way knowledge is transmitted around, the mobility of employees seems to be a channel, which should not be neglected in the knowledge management perspective. Whether the human mobility is measured by work place mobility in the work career, education place mobility, scientific fields mobility or simply as annual job mobility is not important. All measures have a validity describing various places where knowledge transmission processes are possible.

An actual account of the amount and value of knowledge involved in the physical mobility of employees would be a natural next step in the analysis of the knowledge transmission in the knowledge management perspective. This would also allow a better translation between the knowledge accumulation and diffusion and the consequential economic growth. However, such data has not been collected yet, since it is extremely difficult to measure, quantify and generalize individual specific tacit knowledge as well as organisation specific knowledge. Measuring, quantifying and generalising this must be the next step in the process that links knowledge management with economic performance and growth.

References

- Langberg Kamma and Per Stig Lauridsen. 2001. 2001/5: Universitetsforskernes arbejdsvilkår og holdninger til forskningens og forskeres vilkår - hovedresultater (In Danish. *University researchers' work and research conditions and their attitudes towards research. Main results.*) AFSK Report 2001-5.
- Graversen Ebbe. 1999. *Formal competencies in the Danish National Innovation System.* AFSK Report 1999-4.
- Graversen Ebbe. 2000. *Cyclicalities of Mobility Rates on Human Capital – Evidence from Danish register data, 1988-97.* AFSK WP 2000-5.
- Ebbe K. Graversen. 2000. *Human Capital Mobility – A Comparable Knowledge Indicator for the Nordic Countries.* Forthcoming in: Willemaus et al (eds.), 'Science and Technology indicators in the Nordic countries'. Nordic Council of Ministers.
- Ebbe K. Graversen. 2000. *Mobility Rates from Register Data – Comparability among four Nordic Countries.* Forthcoming in: Holm and Pilegaard (eds.), 'Methodology and use of Nordic register data'. Nordic Council of Ministers.
- Kallehauge Pia and Kamma Langberg. 1999. *Researchers at sector research institutions: Work conditions and attitudes.* (In Danish: Forskere på sektorforskningsinstitutioner. Arbejdsvilkår og holdninger til arbejdet). AFSK Report 1999 -6.
- Lundvall. 1992. *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning.* Frances Pinter, London.
- Nonaka Ikujiro, Umeno Katsuhiko and Sasagi Keigo. 1998. *Three tales of Knowledge-creating Companies* In van Krogh Georg, Johan Roos and Dirk Kleime (eds.). *Knowing in Firms.* Sage, London.
- Romer Paul. 1986. *Increasing Returns and Long Run Growth.* Journal of Political Economy, 94.
- Romer Paul. 1990. *Endogenous Technological Change.* Journal of Political Economy, 98.
- Salter Ammon and Ben Martin. 1999. *The Economic Benefits of Publicly Funded Basic Research: A Critical Review.* SPRU WP 34.
- Venzin Markus, Georg van Krogh and Johan Roos. 1998. *Future Research into Knowledge Management.* In van Krogh Georg, Johan Roos and Dirk Kleime (eds.) *Knowing in Firms.* Sage, London.