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Job Mobility for the HRST population - Implications and evidence from register data[*)]

by

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Abstract

This paper examines how the knowledge diffusion and circulation caused by job mobility of employees are influenced by which subgroup of the labour force that is analysed. The population investigated is the group defined as the Human Resources in Science and Technology, HRST. The HRST population is either highly educated or employed in jobs with innovation potentials, c.f. the Canberra Manual (1995). The HRST work force is an important determinant of the innovation power in the knowledge economy where both the narrowly defined R&D and the more broadly defined innovation are significant contributors to economic growth. The job mobility of the HRST population indicates how well knowledge is circulated, exchanged and accumulated in the economy. Mobility of employees, especially the innovative HRST employees, is a significant building stone in the National Innovation System.

The paper investigates the consequences of different HRST definitions based on combinations of educational or occupational information. The educational identifier can be used generally while the occupational identifier requires that the worker must be employed before it is defined. The two identifiers respectively give the HRST-Education and the HRST-Occupation subgroups of the HRST population. In common they define the core group, HRST-Core, of HRST. An analysis of the consequences of variations in the definition of HRST concludes this part of the paper.

Next, this paper presents matrices on into-job and job-to-job mobility rates for the HRST population and for the more narrowly defined scientists and engineers, S&E, population. Mobility matrices of the job mobility between sectors are used to determine the diffusion and circulation of high-level knowledge, i.e. the diffusion of innovation capacity in the National Innovation System.

Finally, the paper shows the distribution of job mobility among the HRST workers and refers estimation results on the mobility probability and the number of individual job shifts in a period of ten years. A variety of explanatory variables is used in these regressions; for example the GDP real growth rate, which determines business cycle influence, age group, educational level, and work place size variables among others to determine individual specific effects as well as other demand effects.

The decomposition of the HRST population shows a core group on 40 percent. 85 percent of the HRST population is employed and the HRST population makes up nearly 35 percent of the labour force. The into-job mobility for the employees is high around 20-25 percent depending on the HRST population of interest. Hence, the knowledge diffusion among the HRST population is

large and significant in Denmark giving support to an innovation friendly environment with regard to knowledge resources, i.e. the National Innovation System, which is capable of handling new inventions all over the economy and augmenting the economic growth rate permanently.

Keywords: Human Resources in Science and Technology, Human Capital Mobility, Knowledge Circulation, Employee Mobility.

JEL codes: J21, J44, J62

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Tables and figures

1. Introduction[1]

Knowledge accumulation and knowledge diffusion are fundamental explanatory parts in newer economic growth theory, c.f. Romer (1986) among others. Hence, the amount of physical mobility of knowledge workers has an immediate influence on the economy. The higher the knowledge level the more able is the economy to innovate and implement innovations. Similarly, a significant mobility of highly educated or innovation important workers secures a diffusion and circulation of the tacit knowledge that increases the overall knowledge level and innovation ability through on-the-job knowledge exchange, i.e. learning-by-doing c.f. Arrow (1962).

The paper examines the mobility of employees and the consequential knowledge diffusion and circulation for the subgroup of the labour force defined as Human Resources in Science and Technology, HRST. The HRST population is either highly educated or employed in jobs with innovation potentials, i.e. professionals or technicians, c.f. the Canberra Manual (1995). The HRST work force is an important determinant of the innovation power in the knowledge economy where both the narrowly defined R&D and the more broadly defined innovation are significant contributors to economic growth, c.f. Tsipouri (2001).[2]

The job mobility of the HRST population indicates how well the knowledge is circulated, exchanged and accumulated in the economy. Mobility of employees, especially the innovative HRST employees, is a significant building stone in the National Innovation System, c.f. OECD (1997, 1999). Knowledge embodied in HRST population on the labour market is important for the establishments but also for the economy. A continuously steady circulation of knowledge, i.e. employees, between firms or research organisations fulfils two objectives, circulating new knowledge and increasing the performance and efficiency of the work force, i.e. creating possibilities for additional economic growth.

The paper investigates the consequences of different HRST definitions based on combinations of educational or occupational information. The educational identifier can be used generally while the occupational identifier requires that the worker must be employed before it is defined. The two identifiers give the HRSTE and the HRSTO subgroups of the HRST population respectively. In common they define the core group, HRSTC, of HRST, see Table 1. An analysis

[1] This paper is part of a larger study at The Danish Institute for Studies in Research and Research Policy on knowledge mobility and benchmarks on decomposed human mobility rates. The study is also a part of a Nordic research project on competence flows and a part of an OECD Focus Group research project on job mobility and human resources.

[2] Innovation power is defined as the economy's ability to innovate, i.e. to develop and implement new inventions.

of the consequences of variations in the definition of HRST for the mobility rates concludes Section 2 of the paper and continues more detailed in Section 4.

Section 3 defines more specifically the job mobility rates used in the paper. Both the implications from the use of register data, the definitions of job mobility as well as an overview of some stylized facts concerning job mobility rates are given in this section.

In Section 4, the paper decompose job-to-job mobility rates by delivering and receiving job sector for the HRST population as well as for the more narrowly defined scientists and engineers, S&E, population. Mobility matrices between sectors are used to determine the diffusion and circulation of the high-level knowledge, i.e. the diffusion of innovation capacity in the National Innovation System. Similarly, the overall into job mobility rates are decomposed by previous job state and recent job sector for both the HRST and the S&E populations.

In Section 4, the paper presents several probability models estimated both on the mobility probability and on the number of job shifts in a ten-year period. The models are estimated for the different HRST populations and the outcomes are compared. A variety of explanatory variables is used in these regressions; for example the GDP real growth rate, which determines business cycle influence, age group, educational level, and work place size variables among others to determine individual specific effects as well as technology, sectoral and economic scale effects.

1.1 Which knowledge types are innovative?

There is a common agreement on the positive influence from innovation on national growth. It is also agreed that the HRST is the main innovating population, c.f. Canberra Manual (1995). Unfortunately, there are several problems defining what part of the HRST population that actually are innovative, c.f. Ekeland (1998). Even though knowledge and knowledge diffusion may create the environment where higher economic growth is possible knowledge in itself is not innovative. It has to be used in an innovation set up.

Endogenous growth models by for example 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. However, the production efficiency is still very often linked to the production sectors even though everybody agrees on the importance of the new knowledge economy, c.f. OECD (1997). Hence, it may be important to strengthen up the definition of the innovative population contrary to the less precise

HRST population. The definition of the HRST population in the Canberra do cover the innovative population but it also covers a lot of other groups who are less innovative.

The scientists and engineers are a core group of innovative people for technological R&D, but there are also other professionals as well as technicians who are innovative. Usually, the physical, mathematical and engineering together with the life science and health scientific fields are seen as the occupations, which are able of handling and implementing technological innovations. Contrarily, high educated teachers, lawyers or high-educated publicly employed administrators may not perform research at all, although they may be innovative in the sense that they increase productivity trough their ability to implement new inventions.

However, at least some of the population groups included in the original Canberra definition of the HRST must be neglected in an immediate translation of HRST to innovation. At best the HRST population gives a measure of the innovation potential in a country. For example, unemployed people, people employed in non S&T job and inactive people should be excluded in the innovation performance measure but may be included in the innovation potential measure. Hence, there is a trade off between broad easy definitions of the innovative population and a definition of the core innovative population.

For example, Denmark has a large public sector employing a large fraction of the high-educated people in job that are not usually thought as innovative. This may be in professional job category such as doctor, lawyer, teacher, accountant, journalist, artist or even priest. This may also be in technician jobs such as photographer, nurse, bookkeeper, physiotherapist, pre-school teacher or secretary. The high-educated individuals are included through the education while the others are included through their occupation. However, neither group may be innovative at all. Due to gender differences in the choices of educations like social science or teaching, the HRST population may even become female dominated, which at least a priori is unexpected.

This means that large fractions of the HRST population are non-innovative, which raises thoughts of how to redefine such a measure to the innovative part of the HRST population. It also means that country-specific HRST populations may be difficult to compare using the existing measure, since high-educated individuals in humanities and social sciences ends together with individuals in natural sciences and medicine. Having the same HRST population share in two countries do not necessarily mean that they have the same relative innovation.

1.2 Knowledge and economic growth

The original growth model by Solow operates with capital and labour as the only input factors. These two factors are, however, only able to explain parts of the empirical figures on growth. The Solow model claims that the growth rate in the long run equalizes between countries. This is not empirically evident since countries are observed with different growth rates, also in the long run. Hence, there is a residual, which cannot directly be explained in these models. This residual, which often has been called the total factor productivity, TFP, is necessary to augment the output of the two inputs to equal the observed growth levels. The TFP has been explored in various studies and one of the explanations is among others that the TFP reveals differences in technical progress, in knowledge levels, and in innovation abilities. So, knowledge and knowledge diffusion may create the environment where higher economic growth is possible with the same input of capital and labour. The latter argument is defended in Mankiw et al (1992) in a study that supports an extended version of Solows model, where physical capital is separated from knowledge capital. However, the empirical evidence in the study seems to depend highly on the included countries. A smaller study on OECD countries does not reveal the same support.

The newer endogenous growth models developed in the 1980s and 1990s have all tried to decompose and explain the TFP part of the neoclassic growth model. Usually the empirical outcome is a model which in practice, although not theoretically is an augmented version of the original Solow model. 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 the quality of the knowledge stock determines the economic growth, not the population size, i.e. the stock of humans. In his model he finds that investment in knowledge is a deliberate decision made by the firms (and the government) in order to improve productivity (and efficiency) in the economy. The investment decision is driven by an equilibrium with monopolistic competition in the markets. Hence, technological improvements (the TFP factor) are driven by a usually higher than normal profit argument, which can be maintained at least in the short run.[3] Lundvall (1992) argues that the channels, in which the knowledge is spread, are as important as the knowledge creation itself. Hence, networks, institutional structures, new candidates as knowledge carriers that diffuses the newest research knowledge, so all parts of the economy, in an efficient way, can handle this and become innovatively up to date. This also means that a country or a firm/university can loose growth if

[3] Harris and Trainor (1995) finds strong evidence in Ireland for the fact that monopolistic competition increases R&D and that monopoly decreases R&D, i.e. that monopolistic competition increases economic growth and that monopoly decreases economic growth.

some research areas are totally abandoned, since nobody in this case can use or implement innovation results from other sources, c.f. Salter and Martin (1999). Hence, a diffusion of employees through job mobility to all sectors in the economy is preferable.

The knowledge and innovation created at publicly owned universities and research institutes contribute to the diffusion of highly educated potentially innovative workers to the economy. The social value of the candidate production and mobility of researchers are usually far above the corresponding private value, c.f. Salter and Martin (1999). 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. A study of first or second job choices among newly graduated employees may support this.

From a community point of view, an effective circulation of the publicly providing knowledge increase is important for the economic growth in the economy. Externalities in the private investments in new knowledge causes the social returns from investment in knowledge to be higher than the private returns to the firms or individuals, c.f. Firth and Mellor (2000). Hence, there are cases where the public sector, i.e. public universities and research institutions, may invest in profitable knowledge improvements that would not be performed otherwise. Afterwards, efficient knowledge infrastructures where HRST employees move between jobs are of vital importance in order to create the social return that justifies a public investment. A considerable mobility rate is preferable to diffuse and collect new knowledge. However, a too high mobility is not preferable, because it takes time to exchange and obtain new knowledge, i.e. the community return from job mobility among workers is a bell shaped function of the mobility rates. A too low and a too high mobility reduce the community return. Unfortunately, there is no clear evidence showing at which mobility rate the community return is maximized.

2. The importance of definitions on the HRST population

Accepting that human capital is important for innovation and economic growth in knowledge-based economies, c.f. Laafia (2000) and Eurostat (2001) raises an interest for measures on the highly qualified cohorts in the economy. The Canberra Manual (1995) uniquely defines a cohort of highly qualified workers, namely the HRST population. The HRST population of innovative workers is especially interesting since its relative size correlates positively with economic growth as mentioned above, but also because it is a group of the labour force on which there is a common definition based on an international cooperation resulting in the Canberra manual, i.e. it allows for comparable figures across countries. However, the HRST definition does not only

identify highly qualified workers, it also includes non-innovative workers as well as it excludes other that are innovative in other job categories, c.f. Ekeland (1998). The pros and cons of the definition of the HRST population in the Canberra Manual have been discussed extensively in the literature, for example Ekeland (1998) and Laafia and Stimpson (2000). In the present paper, some of the empirical possibilities and consequences will be analysed.

In the original definitions in the Canberra Manual, managers without third level education were included in the HRSTO population. A sensitivity study in 1995 indicated that large variations in country definitions of managers distorted the figures considerably, c.f. Laafia and Stimpson (2000). Hence, Eurostat excludes these managers in later studies. So do we in this paper, since it is evident that a first improvement of the HRST definition lies here.

According to the Canberra manual a HRST person fulfils the following conditions:

- Completed third level education corresponding to bachelors, candidates, master etc. measured by the ISCED code, c.f. UNESCO (1976, 1997)

or

- Employed in a science and technology occupation that usually requires third level education measured by the ISCO code, c.f. ILO (1988).[4]

Inspired by Laafia (2000) the two requirements defining the HRST population are presented more schematically in Table 1 where the HRSTE population together with the HRSTO population add to the HRST population. As Table 1 shows, the HRST population also includes non-working people. The employees fulfilling both criteria are mentioned as the core HRST population.

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Table 1: Categories of the HRST population

The HRST population		Education[5]		
		3rd level education ISCED76={5,6,7}	Below 3rd level education ISCED76 < 5	Total
Occupation	Managers Professionals Technicians	HRST Core	HRST Without 3rd level education	HRSTO
	Other occupations	HRST Non-core		HRSTN
	Unemployed or Inactive	HRST Unemployed / HRST Inactive		HRSTU / HRSTI
Total		HRSTE	HRSTW	**HRST**

Note: See footnote 4 above for reason to exclude low educated managers from the HRST population.

Although the HRST population is defined on the basis of two well-implemented classifications, ISCED and ISCO, the HRST population is influenced by national variations in the implementation of these. For example, the HRSTE part includes unemployed and inactive persons although they do not have a formal job. Hence, they are included in the population stock, but not in the stock of workers. Contrarily, the HRSTO part is only identified for workers, i.e. persons with an occupation. An unemployed person, previously employed as a technician, only counts in the HRST population if and only if the person has a third level education. In such cases, increases or decreases in the HRST population can be caused by external factors such as business cycle fluctuations. Especially in comparisons of the HRST stock over time or between countries, this is an important objection against an uncritical use of the HRST definition.

In order to set some numbers on the sensitiveness of the definition of the HRST population, actual numbers are given in Table 2. Table 2 is build up like Table 1 and illustrates how many, more or less, that are included in the HRST stock depending on whether workers solely or everybody are included, i.e. the HRSTO, HRSTE or HRST population. The numbers are averages for the period 1988-97. Similar numbers for the year 1991 and 1997 are given in Tables A1 and A2 in Appendix 2. As Figure 1 also shows, the HRST population share of the labour force is slightly increasing in the period. However, the share of the labour force is relatively stable over the period so the average numbers for the period 1988-97 in Table 2 is a representative measure on the HRST stock since the labour force has been very stable in the period of interest.

[5] ISCED76 is used in the table although a new ISCED97 is implemented form 1998 and forwards. In the ISCED97 third level education corresponds to the values 5a, 5b and 6.

Table 2: The average HRST population in Denmark in the 1990s in thousands. Share of the total HRST in brackets and the male share in each subgroup in parenthesis

The HRST population		Education		
		3rd level education ISCED76={5,6,7}	Below 3rd level education ISCED76 < 5	Total
Occupation	Managers Professionals Technicians	386 [42] (46)	243 [26] (51)	629 [68] (48)
	Other occupations	139 [15] (58)		139 [15] (58)
	Unemployed or Inactive	159 [17] (48)		159 [17] (48)
Total		684 [74] (49)	243 [26] (51)	**927 [100] (49)**

Note: Average number of persons in the period 1988-97.

The HRST stock in Denmark in the 1990s is, according to the register data, approximately one million persons. Compared to Eurostat (2001) numbers, referred in Appendix Table A.4 for 1999 based on the Community Labour Force Survey, CLFS, the numbers in Table 2 are around 75-80 percent of their figures no matter whether the HRST, HRSTE, HRSTO or HRSTC definition is used. Even though the stock is increasing in the period, which gives a stock in 1999 that is larger than the average stock in the 1990s, it seems likely that either the registers underreport the actual status of the individuals or that individuals over-report their status in the CLFS. Reality may be somewhere in between. The differences pinpoints the caution involved in comparison of figures based on different data sources. Since the difference between the numbers in Table 2 and the numbers from the CLFS seems to be general in all categories, the distribution of people in the different categories in Table 2 is assumed to be representative for a general analysis. Similar can be concluded regarding the CLFS data.

The core group, the HRSTC population, amounts to 42 percent of the total HRST population. The remaining part of the HRSTO population amounts to 26 percent of total. Hence, the remaining 32 percent is either employed in a non-S&T occupations, 15 percent, or is not employed at all, 17 percent. The exclusion of the latter group has considerable impact on the conclusions drawn from HRST studies. Using, for example, the employees in S&T occupations, HRSTO, or the highly educated, HRSTE, solely underestimates the HRST population stock by approximately 25 percent.

26 percent of the HRST population has education below the third level. This corresponds to 39 percent of the workers in S&T occupations, i.e. the HRSTO. Similarly 56 percent of the highly

educated works in S&T jobs, i.e. the HRSTC group, while 68 percent of the total HRST population does the same, i.e. the HRSTO group in total.

The overall approximate fifty-fifty gender distribution varies between the subgroups of the HRST population; from 46 percent men in the HRSTC group to 58 percent men in the HRSTN group. However these fluctuations are also found in the CLFS data in Table A.1. The below average share in the HRSTC group is caused by the large fraction of female dominated educations included among the professional and technicians, for example lawyers, teachers or nurses in Denmark. The gender shares also illustrate the danger of a strict focus on the HRSTC group alone neglecting the other subgroups of the HRST population. At least in a country like Denmark, the HRSTC group will not solely include innovative employees. As expected, the gender inequality in favour of men in the stock is much more pronounced when the scientists and engineers alone are analysed, c.f. Table 3 below.

The science and engineering subgroup is another interesting subgroup of HRSTO since it consists of the physical, mathematical and engineering professionals and the life science and health professionals, also abbreviated S&E population. The formal definition is occupation code ISCO equal 21 or 22, which cover the occupations mentioned above together with an employment requirement. The S&E group is directly transferable to the ability of handling and implementing technological innovations. For example, the S&E worker is on average more innovative than the HRST worker, c.f. Eurostat (2001), and the S&E population is of high policy interest in the development of the European Research Area, which is implemented in the ideas behind the forthcoming 6th EU Framework Programme for Research and Technological Development, RTD, c.f. Laafia and Stimpson (2000) and European Commission (2000) among others. Empirical figures for the stock of S&E workers over time is given in Figure 1, while job mobility rates are given in Section 4.2. The average stock is given below in Table 3. Here, the gender difference is remarkably clear although as expected; two-third is men while one-third is women.

Table 3: The average S&E population in Denmark in the 1990s in thousands. Share of the total S&E in brackets and the male share in each subgroup in parenthesis

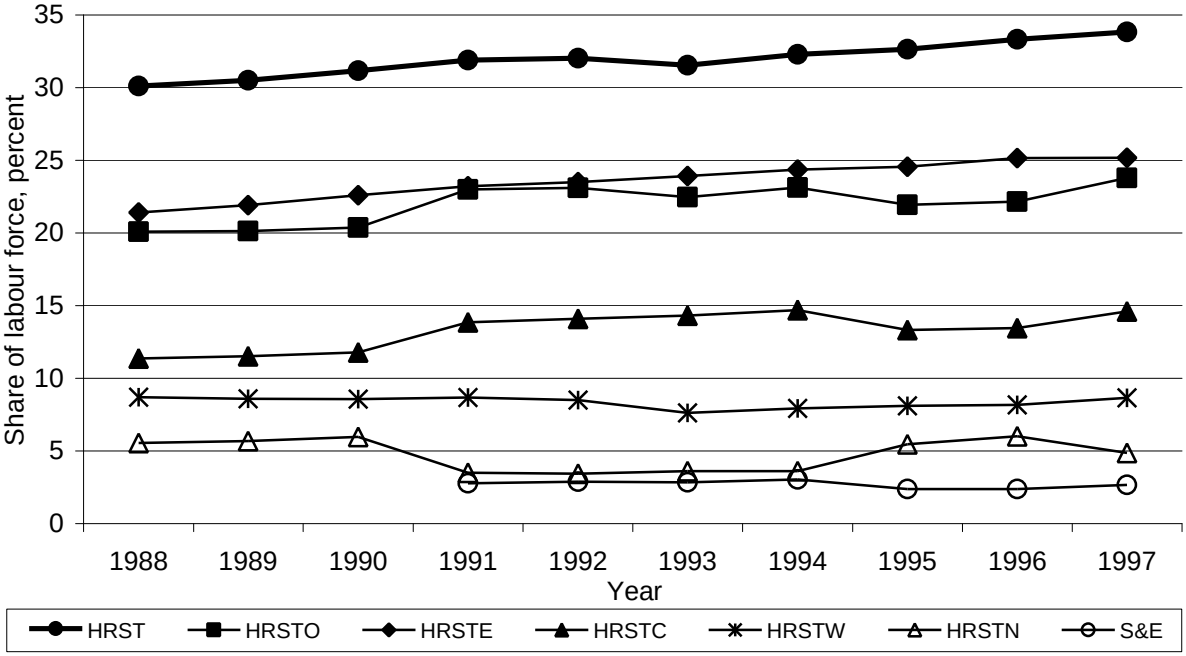
The S&E population	**Education**		
	3rd level education ISCED76={5,6,7}	Below 3rd level education ISCED76 < 5	Total
Professionals	67 [85] (71)	12 [15] (79)	79 [100] (72)

Note: Average number of persons in the period 1991-97.

Again, the figures based on register data are lower than the corresponding figures based on the CLFS in Eurostat (2001), referred in Table A.2 in the Appendix. This time the difference is larger, around 70 percent compared with the CLFS numbers from 1997. It seems to be the case that the register data has some problems identifying the occupation on a two-digit level. Several employees are found in the data with an ISCO code 20, which is a non-existing ISCO code. It is used in the registers when a person is a professional, ISCO=2x, but no information is known on the second digit. The solution is to use the code 20, which is a unique Danish solution chosen by Statistics Denmark. The problem is also mentioned in Laafia and Stimpson (2000) for the Danish part of the CLFS. Hence, the figures in Table 3, defined as ISCO equal 21 and 22 are under-representing the actual stock of S&E in Denmark. A raw approximate number for the S&E stock in the 1990s lies probably around 100000, above the stock in Table 3 and a little below the figure on 113000 in Laafia (2000) for 1997. Eurostat (2001) finds a S&E stock on 140000 for the year 1999.

Figure 1 shows the HRST stock in Denmark relative to the labour force. The total HRST population is increasing in the period as also found in Eurostat (2001). However the increase is happening among the high-educated individuals, i.e. the HRST and the HRSTE shares develop parallel. Oppositely, the HRSTO and the HRSTC population share only increase slightly while the low educated S&T employees, HRSTW, share is at best constant. The development of the shares in the different subgroups illustrates that a measure of the innovation ability may be possible to create based on the HRSTE population alone. Given that the HRSTE population is better defined across countries than the implementation of the occupational code, this may be a better comparable measure on the country specific innovation ability. However, even though the share of the labour force working in S&T occupations is stable, the stock still matters for the actual innovation performance and growth.

Figure 1: The stock of HRST and selected subpopulations, 1988-97. Share of labour force



Note: Due to missing information high-educated managers are not included in the HRSTO definition in the period 1988-90. Instead they are included in the HRSTN subgroup. Hence, the HRSTO population increases and the HRSTN population decrease from 1990 to 1991.

Since one aim of the study is to present mobility rates for the HRST population, it is of interest to find the rates for the various subgroups of the population. Table 4 refers mobility rates for the three HRST groups, HRST, HRSTO and HRSTE, and for the S&E group. The job-to-job mobility rate and the overall mobility rate, c.f. Box 1, are calculated.

Table 4: Mobility rates for different HRST subpopulations

HRST type Þ ß **Mobility type**	HRST	HRSTO	HRSTE	S&E
Job-to-job inflow mobility rates	19.0	18.1	19.5	21.3
Overall inflow mobility rates	25.0	23.0	26.0	26.1

Note: The mobility rates are defined in Box 1 in Section 3. Numbers are averages for the period 1988-97.

Both job mobility rate measures are biased downwards if only the HRSTO population is used in the calculation and biased upwards when only the HRSTE population is used. However, the bias is relatively low and least for the HRSTE population compared to the total HRST population. Hence, if information on occupation or education is missing it is still possible to calculate and use mobility rates that are fairly representative for the HRST population. Finally, the mobility rates for the S&E population are highest, even higher than the HRSTE figures. This means that the S&E population has mobility rates that are 5-10 percent higher than the HRST population in general. Especially, the job-to-job mobility rate is relatively higher for the S&E population. These findings

are also confirmed over time as illustrated in Appendix 3, Figures A1 and A2 showing mobility rates over time, 1988-97, for the four subsamples from Table 4. The mobility rate for the HRSTO population is lowest in all years. Similarly, the mobility rate for the S&E population lies in the top in all years.

3. Register data, mobility rates and stylized facts

The use of register data in studies of knowledge circulation in form of physical mobility has pros as well as cons. [6] The registers cover everybody employed at the establishment level, so there are no sample errors in the data. The employees can be followed forth and back in time as long as they have been living in Denmark. Unfortunately, the employer who has no other than legal incentives to correct the codes if they change for the employees gives individuals occupational codes. Hence, some of the codes may be outdated. Similarly, more specialized information such as titles, which may be of importance in a clarification of the occupations, are not immediately available. Such information can more accurately be collected in surveys although these often miss the time dimension and have sample errors.

Another speciality in registers is the period of coverage, usually one year. Hence, the information on occupation comes from the main job in the year and job mobility as well as job sector is 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 count employees once even though they may move job more than once per year. The registers also lack information on education among foreigners working in Denmark. Hence, the labour force includes these employees, but they are registered without education. This reduces the HRST population with an unknown factor, which may lie around five percent if foreigners are educated similarly as Danes.

The job mobility and the job mobility rate can be defined in various ways. Box 1 gives the definitions used in the present paper. The distinguishing between job-to-job mobility and overall mobility is explained together with the corresponding mobility rates. Only inflow mobility e.g. into job mobility is used in this paper.

[6] The register database IDA is used in the present study. 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. We use data for the period 1988-97.

Box 1: Definitions of job mobility terms

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, i.e. MOVERS.
- **Overall job mobility** is defined as MOVERS plus NEWS moving into job from the no-job state,
  i.e. ALL MOVERS = MOVERS + NEWS.
- **No mobility** is defined as the total number of employees who are employed at the same workplace both years, i.e. STAYERS.

2. Inflow mobility rate

- The **job-to-job inflow mobility rate** is defined as the number of employed movers between two consecutive years divided by the total number of employees this year, i.e. MOVERS / (ALL EMPLOYEES).
- The **overall inflow mobility rate** is defined as the number of employees not having the same job the previous year divided by the total number of employees this year, i.e. ALL MOVERS / (ALL EMPLOYEES).

A previous study by Graversen (2000) and Graversen et al (2001) gives some stylized facts on how the job mobility rates vary over the business cycle and over some of the background characteristics used as explanatories in the model in Section 4.The findings are given in Table 5 below and are based on studies of the Nordic countries using register data. Although the findings cannot directly be transferred to the HRST population they can explain some of the variations, trends and systematic differences that are found in Section 4. Generally, there is a high mobility of workers in the Nordic countries, around 25 percent shifts job each year. The rates are higher in economic upturns, among young people, among high-educated individuals and among workers at small work places, all compared to the opposite characteristics.

Table 5: Trends in inflow job-to-job mobility rates by background characteristics for the Nordic countries

Background characteristics	Tendency and trend in the ordering and cyclicality
Generally on average	• Significant job mobility among all subgroups on the labour market. Mobility rates around and above 20 percent • Procyclicality in the job mobility rates when the GDP real growth rate proxies the business cycle
Sector	• The sector effect is not clear. The HEI sector seems to have low mobility rates, the ICT sector seems to have high rates. In between it seems to matter for the mobility rates whether the sectors are shrinking (agriculture) or expanding (trade) • The business cycle matters, most volatile for the youngest, least volatile for the HEI and the ICT sectors
Age	• The age effect is very dominating. The mobility rate decreases in all Nordic countries by age • The business cycle matters for all age groups although apparently most volatile for the youngest
Education	• The educational effect is also clear. The mobility rate increases the higher educational level • The business cycle matters for all groups although apparently most volatile for the low educated
Work place size	• The work place size matters clearly. The mobility rate decreases the larger the work place • A business cycle effect is seen for all groups apparently most volatile for small work places

Source: Graversen et al (2001).

4. Job mobility rates for the HRST labour force

In the following section, the mobility rate for the HRST population is analysed more deeply. The average job mobility over time as well as the mobility rates decomposed by selected background characteristics is presented.

First, an input-output matrix tables of delivering and receiving job sectors for the mobile workers is presented together with a similar table of previous job state and receiving job sector for the HRST population in Tables 6 and 7. Similar tables are given for the S&E population in Tables 8 and 9. The job-to-job and the overall mobility rates presented in Table 4 for the HRST and the S&E population can also be found in Tables 7 and 9. Next, the distribution of the job mobility rates is illustrated in Figures 2 and 3 for a sample present in 1988 and for the entire work force in the period 1988-97, separately. Finally, a model on the probability of job changes is estimated on the entire HRST population and subgroups of this together with another model of the number of job shifts in a 10-year period in a balanced sample of the HRST and the S&E population. Only job-to-job mobility is used.

4.1 HRST inflow mobility distributed by sectors and job mobility type

The distribution of the mobile HRST workers by job sector is almost representative for the distribution of all HRST workers by sector as the totals in Table 7 also shows. Hence the mobility rates by sectors do not vary much although there are small differences as Figures A3 and A4 in Appendix 4 illustrates. Hence, the mobility rates are almost equal opposite the pattern in from which sector the mobile workers come from.

The HRST population is somewhat conservative in their choice of a new job when they change from one job to another. Table 6 shows that more than 60 percent of the mobile workers are mobile internally in the sector as the diagonal bold numbers show. However, this is not surprising but rather expectable since it seems less natural to move across sectors than internal, i.e. between comparable jobs. When this is noted, the remaining mobile workers also reveal that there is a wide although not dominating diffusion of HRST workers across sectors. Especially the two small size sectors, the HEI and R&D and the ICT, deliver employees to a wide range of other sectors. It is also worth noting that the sector ‘other community services’ receives a large share of the mobile workers from the HEI sector. This is not the case from the two private production and service sectors. Contrarily, the private production sector delivers nearly 25 percent of the mobile workers to the private service sector.

The gender differences in the mobility composition are marked. The inflow of men to the ICT, the production related and the production service related sectors, is above average. Conversely, the inflow of men to the community service sector is below average. These sector differences are also found in the stocks of workers by sector given in Table 7 below. Hence, the present flow of workers does not seem to equalize the gender differences in the working sectors. Contrarily, the flows maintain the existing differences.

Table 6: HRST job-to-job inflow mobility distributed by delivering and receiving sectors. Percent and numbers together with the male share in each subgroup in parenthesis

Receiving sector ⇒ . ⇓ Delivering sector	Higher Education Institutions and R&D Institutes	Information and Communication Technology	Agriculture, mining, manufacturing, utilities and construction	Trade, hotels, restaurants, transport, communication, financial intermediation and other services	Other community services	Row totals in percent	Row shares	Total numbers
Higher Education Institutions and R&D Institutes	**46 (59)**	4 (86)	8 (63)	14 (65)	27 (47)	100	2	4256 (58)
Information and Communication Technology	1 (88)	**47 (80)**	16 (80)	27 (79)	9 (68)	100	2	4480 (79)
Agriculture, mining, manufacturing, utilities and construction	1 (60)	3 (85)	**60 (77)**	23 (75)	13 (55)	100	11	21102 (73)
Trade, hotels, restaurants, transport, communication, financial intermediation and other services	2 (65)	4 (80)	11 (67)	**69 (67)**	15 (42)	100	24	44975 (64)
Other community services	2 (53)	0 (58)	3 (54)	7 (48)	**88 (32)**	100	40	73064 (34)
Unknown sector	5 (57)	2 (74)	15 (63)	27 (54)	52 (29)	100	21	38931 (43)
Column shares	4	3	14	28	51	100	100	
Total numbers	6449 (58)	5621 (79)	26698 (70)	52601 (64)	95439 (33)			186808 (49)

Note: The numbers are averages for the period 1989-97. The table only includes employees with a known sector in the receiving year.

Looking broader on the entire inflow mobility to the five working sectors, Table 7 shows that on average 25 percent of the employees in the sectors are new hired each year. The sum of the first three lines, 19 percentage points of the workers, comes from other workplaces. This is the job-to-job mobility rate given in column 1 in Table 4. Further 6 percentage points had no job the previous year, i.e. the sum of line 4 to 6. The sum, i.e. 25 percent, equals the overall inflow mobility rate for the HRST population in Denmark as also referred in Table 4. It is remarkable that less than five percent of the mobility is internal between work places in the same firm, while 14 percent moves between firms when they change job. The table does not show the inflow of for example new educated graduates since a large part of these already had a job while they were studying. Hence, a part of them goes into the job-to-job mobility rate, a part of them stays at the same work place, and a part of them comes into job from the inactive group.

Table 7: HRST population distributed by overall inflow mobility type and job sectors. Percent and numbers and the male share in each subgroup in parenthesis

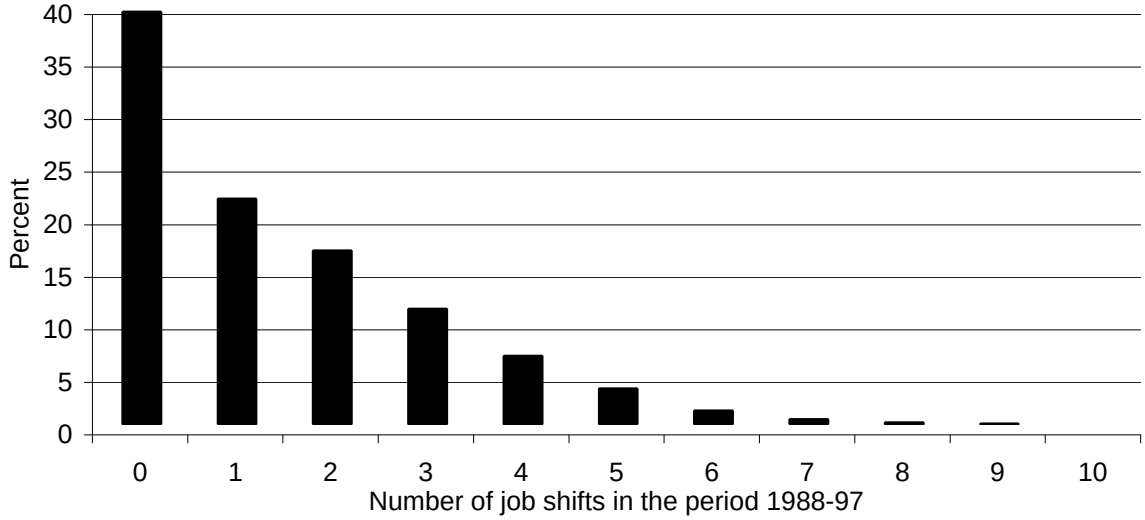
Working sector ⇒ . ⇓ Coming from	Higher Education Institutions and R&D Institutes	Information and Communication Technology	Agriculture, mining, manufacturing, utilities and construction	Trade, hotels, restaurants, transport, communication, financial intermediation and other services	Other community services	Row shares	Total numbers
One work place into another in the same firm	3 (61)	3 (77)	3 (69)	4 (66)	6 (37)	5	36406 (48)
An existing firm into another existing firm	16 (60)	15 (79)	12 (71)	12 (65)	11 (34)	12	88764 (51)
An existing firm into a new established firm	2 (52)	5 (85)	3 (75)	4 (66)	2 (31)	3	20849 (55)
Unemployment into work	2 (57)	2 (82)	2 (64)	2 (54)	2 (28)	2	16091 (42)
Inactive as pensioner or retired into work	6 (54)	2 (71)	3 (60)	3 (52)	3 (29)	3	22169 (42)
Inactive as leaver or migrant into work	1 (58)	1 (59)	1 (66)	1 (58)	1 (24)	1	7421 (38)
Same work place having no mobility	70 (64)	72 (78)	76 (72)	73 (64)	76 (36)	75	575394 (50)
Column totals	100	100	100	100	100		
Column shares	3	3	14	26	54	100	
Total numbers	22325 (62)	20449 (78)	111505 (71)	200426 (64)	412390 (35)		767095 (50)

Note: The numbers are averages for the period 1988-97. Firms are both private and publicly owned.

A remarkable item is the mobility into new established firms. The rate is above average for the ICT and the trade etc. sectors, which means that there is an above average proportion of hiring among new firms in these sectors. There is also an above average mobility rate for internal mobility and inactive for the other community service sector. This is partly caused by the fact that the sector is dominated by large public workplaces that are sector dominating and by the fact that the public sector employs an above average share of job seekers with no previous job experience.

Another measure for mobility of the HRST population is the distribution of the individual mobility propensity. Figure 2 shows the number of job shifts among a selected balanced subsample of the HRST population. The sample is required to fulfil the HRST definition in each of the ten years from 1988 to 1997. Hence, especially the youngest and low educated workers moving in and out of the HRST population through jobs outside the HRST defined groups are excluded.[7] The remaining individuals consist of approximately 310,000 individuals. Approximately 40 percent of these do not shift job at all in the ten-year period. Less than five percent shifts job five times or more. However, the sample is a 'core' sample of HRST individuals over time, so the picture is expected to show low mobility rates. On average the mobility rate is below 15 percent, remarkably lower than the general mobility rates referred in Table 4.

Figure 2: Distribution of job-to-job shifts over a ten-year period for a balanced subsample of the HRST population



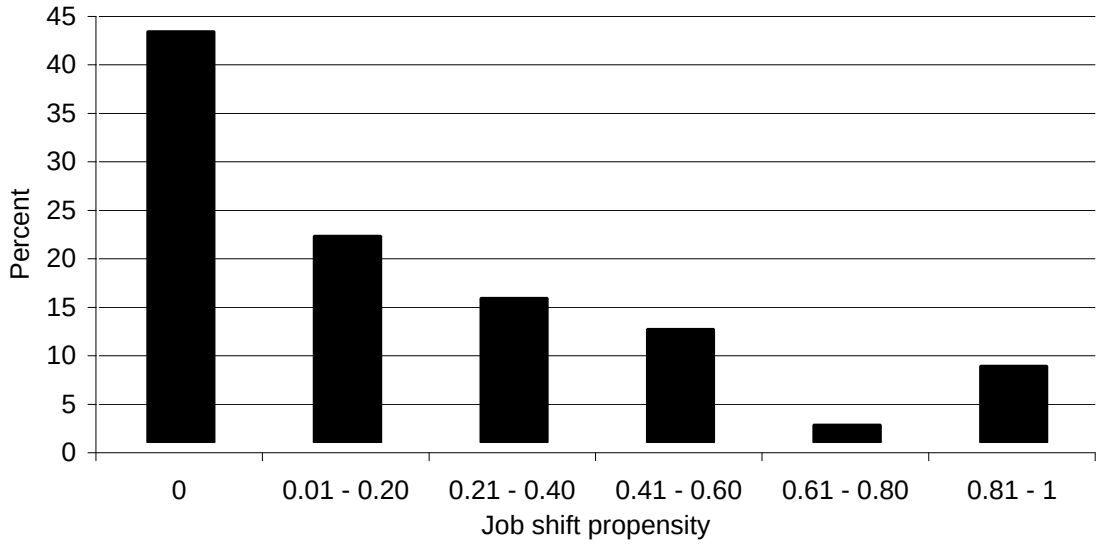
Note: The number of job shifts for each individual is calculated over the period 1988-97 conditional on presence in the HRST sample in all ten years. Hence, the distribution is not representative for the HRST population, only for a selected core group fulfilling the HRST definition in all years.

Figure 3 instead, shows the mobility rate distribution calculated as the average job shift probability, i.e. number of job shifts divided with number of years present as HRST in the database. Each individual present in the HRST population no matter whether the individual fulfil the definition in all ten years or not is included. Naturally, they are only included in these years where they fulfil the definition. The distribution is representative for the HRST population, but the fact that some individuals only temporarily are in the HRST sample causes a peak at 1. These employees move in one year and out the following.

[7] The subsample that is present in all 10 years is highly unrepresentative for the HRST population in general, since it excludes young and/or new educated individuals that join the labour market during the period. Similarly retiring individuals are excluded. However, the remaining sample consists of the more job stable workers, c.f. Graversen (1999).

Still a large group of individuals has no job mobility at all. As in Figure 2, approximately 40 percent of the individuals do not shift job at all in the period they are present in data. The remaining 58 percent of the individuals shift job once or more in the period. A mobility propensity on one in Figure 3 means that the individuals job shift each year they are present. The young employees and others that are present in a few years, some only one year, cause the peak at one. Similarly, the intervals chosen for the mobility propensities in the figure together with the short period it is calculated from can cause ambiguous peaks for some of the groups if finer intervals are used; for example intervals on 0.1 in stead of 0.2 as chosen here. However, the figure is still representative for the HRST population at any time so an individual and time period weighted average of the propensities in Figure 3 gives the mobility rate referred in Table 4.

Figure 3: Distribution of job-to-job mobility propensity for the HRST population, 1988-97



Note: The mobility propensity for each individual is calculated as the average job shift rate in the number of years they are present in the database, i.e. number of job shifts divided by the number of years present. Hence, the distribution lies between 0 and 1 and it is representative for the HRST population.

4.2 Mobility rates for the S&E workers

Making the same exercise for the S&E population, as was done for the HRST population in Section 4.1, shows some similarities but also several differences. As Table 8 shows, there still is large internal sector mobility but also a significant mobility between sectors. In general, a higher share of the S&E population moves to the HEI, ICT and trade etc. sectors compared to the totals in Table 6. However, in absolute numbers the S&E population is much smaller than the HRST population.

Another striking difference is the gender inequality in Table 8. Approximately two-third of the mobile S&E are men. It corresponds to the male share in the S&E population in Tables 3 or 9,

72 percent, although the male share is a bit higher in the stocks compared to the 70 percent among the mobile employees. This may indicate that there is a larger mobility rate among the S&E women compared to the S&E men. However, the estimation results from the models in Tables 10 and A3 reject this when the mobility rates are corrected for other background differences in the sample. Actually, Table 10 shows the opposite, namely that the male mobility rate is higher than the female mobility rate holding everything else equal. The male dominance is remarkably clear in the ICT sector while the gender difference vanishes in the other community service sector, which mainly covers jobs in the public sector.

Table 8: S&E workers job-to-job inflow mobility distributed by delivering and receiving sectors. Percent and numbers and the male share in each subgroup in parenthesis

Receiving sector ⇒ . ⇓ Delivering sector	Higher Education Institutions and R&D Institutes	Information and Communication Technology	Agriculture, mining, manufacturing, utilities and construction	Trade, hotels, restaurants, transport, communication, financial intermediation and other services	Other community services	Row totals in percent	Row shares	Total numbers
Higher Education Institutions and R&D Institutes	**38 (69)**	5 (95)	11 (78)	19 (74)	26 (54)	100	4	893 (69)
Information and Communication Technology	1 (92)	**52 (87)**	15 (82)	25 (90)	6 (96)	100	8	1658 (88)
Agriculture, mining, manufacturing, utilities and construction	3 (69)	4 (79)	**70 (89)**	19 (92)	4 (74)	100	16	3334 (88)
Trade, hotels, restaurants, transport, communication, financial intermediation and other services	2 (73)	14 (91)	14 (86)	**59 (82)**	10 (66)	100	24	4807 (82)
Other community services	3 (64)	1 (93)	2 (80)	5 (71)	**89 (49)**	100	32	6542 (52)
Unknown sector	8 (72)	8 (84)	27 (77)	30 (66)	27 (42)	100	16	3203 (64)
Column shares	5	10	22	26	38	100	100	
Total numbers	1018 (70)	2020 (88)	4385 (85)	5341 (80)	7674 (51)			20438 (70)

Note: The numbers are averages for the period 1992-97. The table only includes employees with a known sector in the receiving year.

Table 9 shows that the mobility rates for the S&E population are higher than the corresponding rates for the HRST population. The difference comes from a higher mobility rate of S&E between existing firms. However, still 74 percent of the S&E do not move into a new job. Again the male share is generally around 60-70 percent, largest in the ICT sectors, smallest in the other community sector.

Table 9: S&E workers population distributed by overall inflow mobility type and job sectors. Percent and numbers and the male share in each subgroup in parenthesis

Working sector ⇒ . ⇓ Coming from	Higher Education Institutions and R&D Institutes	Information and Communication Technology	Agriculture, mining, manufacturing, utilities and construction	Trade, hotels, restaurants, transport, communication, financial intermediation and other services	Other community services	Row shares	Total numbers
One work place into another in the same firm	3 (72)	2 (79)	4 (80)	4 (86)	7 (48)	5	3557 (64)
An existing firm into another existing firm	17 (69)	15 (92)	12 (89)	12 (83)	15 (55)	14	10755 (73)
An existing firm into a new established firm	3 (64)	6 (83)	4 (88)	3 (86)	2 (53)	3	2459 (79)
Unemployment into work	5 (75)	2 (96)	3 (81)	2 (68)	1 (48)	2	1626 (70)
Inactive as pensioner or retired into work	4 (68)	1 (80)	2 (70)	1 (58)	1 (37)	2	1304 (57)
Inactive as leaver or migrant into work	2 (79)	1 (60)	1 (86)	1 (69)	1 (31)	1	856 (55)
Same work place having no mobility	66 (78)	73 (88)	75 (89)	77 (84)	73 (48)	74	58075 (73)
Column totals	100	100	100	100	100		
Column shares	4	9	22	29	36	100	
Total numbers	3024 (75)	7342 (88)	17378 (88)	22865 (83)	28023 (49)		78632 (72)

Note: The numbers are averages for the period 1991-97. Firms are both private and publicly owned.

4.3 Probability models on job shift propensities

In this section, a probability model on the job mobility propensity is estimated. A simple logistic model on the probability to move into a job is estimated for the full HRST, the smaller HRSTE and HRSTO as well as the S&E population separately. Additionally, an ordered logistic model on the restricted subsample of the HRST and the S&E population fulfilling the HRST (or S&E) definition in all ten years 1988-97 (or 1991-97) is also estimated. Table 10 presents the results for the job-to-job mobility propensities, while Appendix 2, Table A3 presents estimates for the models on the overall mobility rates, c.f. Box 1. The average into job mobility over time is shown in Figures A1 and A2 in Appendix 3 for the various subgroups. The population-weighted average of these mobility rates is also given in Table 4 for the four HRST groups.
Several background variables mentioned in Table 5 as well as other variables are included in the models. The reference person is a 35-44 years old high-educated woman working in the agriculture etc. sector as a physical, mathematical or engineering science professional (ISCO=21) at an establishment with 1-9 employees. Hence, the coefficients in the table are read as additional effects for a person with a change in this particular characteristic keeping everything else equal compared to the reference person. The estimation results in Table 10 show relative stable coefficients across the samples. Hence, the mobility patterns seem to be relatively identical for all groups fitting well with the stylized facts form Table 5. However, there are some differences in the parameter estimates across the subsamples as will be discussed below.

The GDP real growth rate is used as an approximation to the business cycle. An increase indicates better economic conditions. The positive coefficient to the explanatory variable indicates that the inflow mobility rate is procyclical. A one percent increase in the GDP real growth rate increases the job-to-job mobility rate by 2-3 percent. The coefficients to the balanced (core) samples are generally a little bit higher than for the unbalanced samples, which indicates that the job mobility reactions to the business cycle variations are smaller for the latter group. Especially the balanced sample of HRST workers has a higher reaction to the business cycle changes.

The gender coefficient reveals that the male HRST workers shift job more often than the women. This is less pronounced when the overall mobility rate is used, c.f. Table A.3 in Appendix 2. Hence, men have a higher job mobility rate but more women than men have a period without job before the next appears.

The age dependence is very stable, decreasing in age except for the oldest workers.[8] This is in accordance with both search theory and match theory. It takes some jobs to find the perfect job or the perfect job match. The age variable correlates highly with corresponding variables measuring job experience and job tenure. Since, these are more difficult to measure exactly in for example surveys, the age variable is chosen in the present analysis.

[8] Possibilities for early retirement, part time jobs and pension etc. increase the mobility rates among the oldest workers.

Table 10: Job-to-job mobility propensities for the HRST population in Denmark 1991-97. Logistic models on pooled datasets

Population / Explanatory variables	HRST	HRSTO	HRSTE	S&E	HRST	S&E
	---------- Binary logit model ----------				Ordered logit model	
Business cycle indicator[9]						
GDP real growth rate	0.026*	0.030*	0.024*	0.022*	0.072*	0.029*
Gender						
Male	0.113*	0.158*	0.052*	0.308*	0.290*	0.641*
Age groups						
20-24	1.269*	1.320*	1.277*	1.714*	2.098*	1.761*
25-29	0.841*	0.832*	0.944*	0.669*	1.366*	-0.081*
30-34	0.445*	0.476*	0.479*	0.435*	0.749*	0.166*
45-54	-0.380*	-0.386*	-0.385*	-0.501*	-0.670*	-0.992*
55-64	-0.711*	-0.747*	-0.693*	-0.915*	-1.160*	-2.004*
Above 64	-0.232*	-0.192*	-0.232*	-0.491*	-0.621*	-1.046*
Educational level						
1st level	0.266*	0.245*	-	-0.309*	0.275*	-2.833*
2nd level	0.031*	0.005	-	-0.036	-0.130*	-2.261*
PhD	0.158*	0.138*	0.182*	-0.287*	0.381*	-2.612*
Working sector						
HEI sector	0.278*	0.231*	0.284*	0.154*	0.119*	0.444*
ICT sector	0.228*	0.241*	0.169*	0.078*	0.174*	0.002
Trade	0.080*	0.097*	0.047*	-0.026*	0.163*	-0.066*
Community service	0.086*	0.059*	0.108*	0.270*	-0.169*	0.181*
Unknown	2.798*	2.924*	2.737*	2.112*	-	0.855
Establishment size						
10-49 employees	-0.201*	-0.274*	-0.200*	-0.105*	-0.206*	0.626*
50-99 employees	-0.269*	-0.337*	-0.288*	0.052*	-0.362*	1.325*
100-249 employees	-0.151*	-0.179*	-0.131*	-0.045*	0.012*	0.707*
More than 249 employees	-0.230*	-0.289*	-0.250*	-0.157*	0.084*	1.174*
Occupational code						
Professionals						
No inf. on discipline	-0.172*	-0.132*	0.125*	-	0.079*	-
Life science and health	0.460*	0.515*	0.418*	0.446*	0.994*	0.820*
Teaching	-0.271*	-0.204*	-0.380*	-	-0.406*	-
Other professionals	0.019*	0.049*	0.008	-	0.238*	-
Technicians						
No inf. on discipline	-0.168*	-0.154*	-0.704*	-	0.955*	-
Physical, mathematical or engineering science	-0.120*	-0.107*	0.076*	-	0.137*	-
Life science and health	-0.030*	0.034	-0.112*	-	-0.042*	-
Teaching	0.214*	0.273*	0.128*	-	0.703*	-
Other technicians	-0.000	0.022*	0.129*	-	0.528*	-
HRST Managers	0.119*	0.240*	0.228*	-	0.293*	-
HRST Non-core	0.211*	-	0.103*	-	0.393*	-
Pseudo-R^2	0.257	0.247	0.211	0.088	0.604	0.303
Number of observations	5077254	4297413	3486651	523954	3105074	149982
Sample	---------- Unbalanced ----------				------- Balanced -------	

Note: The constant terms are omitted in the table, but they can be obtained from the authors. *: Significance at a five percent level. The reference person is a 35-44 years old master educated woman working in the agriculture etc. sector as a physical, mathematical or engineering science professional (ISCO=21) at an establishment with 1-9 employees.

[9] If the inverse unemployment rate is used as the business cycle indicator, the coefficient becomes negative but insignificant for the HRST population, positive and significant for the HRSTO population and negative and significant for the HRSTE population. Hence, the inflow mobility rate becomes procyclical for employed S&T workers and countercyclical for high-educated workers in general when this indicator is used. The other coefficients do not change significantly.

Compared to academics all other HRST workers seem to have higher job mobility rates, except for the S&E, who clearly has lower job mobility rates. Hence, the more stable part of the HRST population, i.e. the academics, moves less often jobs.

Comparing sector specific job mobility rates, the employees in the ICT and the community service sector have the highest mobility rates. Again the S&E is slightly different having the highest job mobility rates in the HEI and the community service sectors. The employees in the unknown sector are few and usually present in only a few periods, i.e. the firm may have missing information on the sector where it belongs.

The job mobility rates decomposed by establishment size, i.e. number of employees only fit the stylized facts given in Table 5 for the unbalanced sample. The rates decrease by establishment size indicating that larger establishments may have larger internal job circulation, that small establishments may need quicker knowledge recruitment due to expansions or that smaller establishments more often emerge (and disappear again) recruiting quickly and firing quickly. However, looking at the balanced sample, especially the S&E has higher job inflow rates, when they are employed at larger establishments. Larger establishments may be more innovative employing more researchers, which give the present findings if the balanced sample indicates a higher rate of researchers among the HRST and S&E population than the unbalanced sample does.

Decomposing the mobility rates by occupation and work discipline reveals a mixed pattern. Compared to the physical, mathematical or engineering science professional, the life science and health professional has generally a higher job mobility rate. Teaching professional has a lower mobility rate. Contrarily, technicians seem to have lower mobility rates except for teaching technicians. Again the balanced sample results differ somewhat. Managers have generally high job mobility rates together with the non-core HRST employees.

In general the coefficients in the estimated models shows the same patterns and tell the same story. Hence, an estimated model based on the smaller HRSTE population may be as good as a model based on the HRSTO population or even the S&E population. However, there are significant differences in the estimated coefficients when a balanced sample is used instead of an unbalanced sample.

A comparison of the estimation results in Table 10 with the corresponding coefficients in Appendix 2; Table A3 shows a similar robustness in the findings. Expanding the subsamples with into job mobility from outside employment does not change significantly in the conclusion

from Table 10. Although the gender differences decrease all other coefficients in Table 10 approximately equal the corresponding coefficients in probability models on the overall mobility rate in Appendix 2, Table A3.

5. Conclusion

The present paper examines how the knowledge diffusion and circulation caused by job mobility of employees are influenced by which subgroup of the labour force that is analysed. The population investigated is the group defined as the Human Resources in Science and Technology, HRST. The HRST population is either highly educated or employed in jobs with innovation potentials, c.f. the Canberra Manual (1995). The HRST work force is an important determinant of the innovation power in the knowledge economy where both the narrowly defined R&D and the more broadly defined innovation are significant contributors to economic growth. The job mobility of the HRST population indicates how well the knowledge is circulated, exchanged and accumulated in the economy. Mobility of employees, especially the innovative HRST employees, is a significant building stone in the National Innovation System causing possibility for economic growth.

This paper investigates the consequences of different HRST definitions based on combinations of educational or occupational information. The educational identifier can be used generally while the occupational identifier requires employment before it is defined. The two identifiers define the HRST-Education and the HRST-Occupation subgroups of the HRST population. In common they define the core group, HRST-Core, of HRST. The core group covers 42 percent of the HRST population with a small female majority. The HRSTO group covers 68 percent and the HRSTE group 74 percent of the HRST population. There is a male majority among the non-core high-educated employees. The subgroup of S&E is highly male dominated, 72 percent. Although the register-based figures underestimate the corresponding CLFS figures, c.f. Eurostat 2001, the distributions are expected to be representative. The job mobility rates for the various HRST subgroups reveal such a high degree of similarity that general comparisons can be made across the subgroups. Hence, for example on mobility rates based on the HRSTE population solely can be approximated to cover the entire HRST population.

Next, this paper presents job-to-job and into job mobility rates for the HRST population and for the more narrowly defined science and engineering, S&E, population. Mobility matrices between delivering and receiving job sectors show a high degree of diffusion and circulation of high-level knowledge across sectors although the main mobility is sector internal. A decomposition of all employees by work status the previous year reveals that one-fifth of the mobile workers shift

establishments in the same firm, two-fifth shifts from another firm, and one-fifth comes from no previous employment. The total mobility rates are on average close to 20-25 percent, i.e. one out of four employees shifts job during a year. It is generally true that register data reveals higher mobility rates than LFS data, c.f. Laafia and Stimpson (2000) and Nås et al (1998).

Additionally, this paper presents estimation results on a probability model on the job shifts for the four HRST samples. An ordered model is also estimated in a balanced sample on the number of individual job shifts in a period of ten years. A variety of explanatory variables is used in these regressions; for example the GDP real growth rate, which determines business cycle influence, age groups, educational levels, and work place sizes variables among others to determine individual specific effects as well as other demand effects. The results are remarkably stable across the four HRST samples although the S&E sample results differ somewhat. In general the estimations from the four unbalanced HRST samples confirm the stylized facts given in Table 10. The balanced sample estimation results differ with respect to establishment size and occupation code. However, this is to be expected since the balanced sample is special fulfilling the HRST definition in all ten years.

The analysis of the HRST population and the consequences of changes or redefinitions of the innovative population shows, that it is important at least for comparison or benchmark reasons to have clear and common definitions of the innovative population. Inclusion of unemployed or inactive high-educated individuals, of low-innovative professionals or technicians like lawyers or nurses, as the HRST definition requires, results in a population stock that are at best an indicator of the innovation ability and not the innovation performance in the economy. Some more precise definition of innovative employees is preferable since it will increase the innovation performance comparability between firms, sectors and countries. However, the cost from such a closer definition may be in form of less generality and large difficulties collecting and creating empirical evidence. The present work on a new HRST definition hopefully solves the contradicting pros and cons in a usable way.

The decomposition of the HRST population shows a core group on 40 percent. 85 percent of the HRST population is employed and the HRST population makes up a little less than 35 percent of the labour force. The into-job mobility for the employees is high around 20-25 percent depending on the population of interest. Hence, the knowledge diffusion among the HRST population is large and significant in Denmark giving support to an innovation friendly environment with regard to knowledge resources, i.e. the National Innovation System, which is capable of handling new inventions all over the economy and augmenting the economic growth rate permanently.

6. References

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Appendix 1: The stock of HRST in 1991 and 1997

Table A1: The HRST population in Denmark in 1991 in thousands. Share of the total HRST in brackets and the male share in each subgroup in parenthesis

The HRST population		Education		
		3rd level education ISCED76={5,6,7}	Below 3rd level education ISCED76 < 5	Total
Occupation	Managers Professionals Technicians	402 [43.5] (47.7)	252 [27.2] (61.5)	654 [70.7] (53.0)
	Other occupations	102 [11.0] (54.0)		102 [11.0] (54.0)
	Unemployed or Inactive	170 [18.3] (47.9)		170 [18.3] (47.9)
Total		674 [72.8] (48.7)	252 [27.2] (61.5)	**926 [100] (52.2)**

Table A2: The HRST population in Denmark in 1997 in thousands. Share of the total HRST in brackets and the male share in each subgroup in parenthesis

The HRST population		Education		
		3rd level education ISCED76={5,6,7}	Below 3rd level education ISCED76 < 5	Total
Occupation	Managers Professionals Technicians	419 [43.2] (44.4)	248 [25.6] (54.8)	667 [68.8] (48.2)
	Other occupations	140 [14.4] (65.1)		140 [14.4] (65.1)
	Unemployed or Inactive	162 [16.8] (46.0)		162 [16.8] (46.0)
Total		721 [74.4] (48.8)	248 [25.6] (54.8)	**969 [100] (50.3)**

Appendix 2: Overall job mobility rates for HRST and selected subpopulations

Table A3: Overall job mobility propensities for the HRST population in Denmark 1991-97. Logistic models on pooled datasets

Population / Explanatory variables	HRST	HRSTO	HRSTE	S&E	HRST	S&E
	---------- Binary logit model ----------				Ordered logit model	
Business cycle indicator						
GDP real growth rate	0.032*	0.038*	0.026*	0.025*	0.075*	0.033*
Gender						
Male	0.027*	0.079*	-0.033*	0.173*	0.262*	0.622*
Age groups						
20-24	1.528*	1.586*	1.544*	2.321*	2.130*	1.669*
25-29	0.982*	0.977*	1.083*	0.964*	1.413*	0.165*
30-34	0.495*	0.532*	0.526*	0.479*	0.772*	0.233*
45-54	-0.411*	-0.416*	-0.404*	-0.533*	-0.676*	-1.003*
55-64	-0.720*	-0.757*	-0.681*	-0.919*	-1.174*	-2.020*
Above 64	0.078*	0.097*	0.019	-0.385*	-0.655*	-1.074*
Educational level						
1st level	0.327*	0.289*	-	-0.089*	0.268*	-2.637*
2nd level	0.022*	-0.019*	-	-0.002	-0.133*	-2.036*
PhD	0.159*	0.105*	0.187*	-0.195*	0.386*	-2.365*
Working sector						
HEI sector	0.402*	0.413*	0.372*	0.320*	0.110*	0.433*
ICT sector	0.115*	0.129*	0.075*	-0.015	0.179*	-0.023
Trade	0.035*	0.050*	0.021*	-0.048*	0.146*	-0.093*
Community service	0.117*	0.116*	0.124*	0.287*	-0.170*	0.201*
Unknown	2.600*	2.720*	2.535*	2.242*	2.392*	0.812
Establishment size						
10-49 employees	-0.279*	-0.361*	-0.265*	-0.130*	-0.211*	0.644*
50-99 employees	-0.355*	-0.417*	-0.367*	-0.027	-0.362*	1.298*
100-249 employees	-0.267*	-0.300*	-0.232*	-0.201*	0.005	0.681*
More than 249 employees	-0.371*	-0.426*	-0.362*	-0.281*	0.065*	1.157*
Occupational code						
Professionals						
No inf. on discipline	0.141*	0.170*	0.437*	-	0.098*	-
Life science and health	0.318*	0.374*	0.282*	0.328*	0.984*	0.819*
Teaching	-0.315*	-0.252*	-0.419*	-	-0.411*	-
Other professionals	-0.027*	0.008	-0.023*	-	0.236*	-
Technicians						
No inf. on discipline	-0.019	-0.006	-0.451*	-	0.966*	-
Physical, mathematical or engineering science	-0.144*	-0.132*	0.067*	-	0.119*	-
Life science and health	-0.133*	-0.077*	-0.247*	-	-0.063*	-
Teaching	0.187*	0.227*	0.129*	-	0.718*	-
Other technicians	-0.096*	-0.070*	0.066*	-	0.552*	-
HRST Managers	0.091*	0.123*	0.109*	-	0.285*	-
HRST Non-core	0.183*	-	0.170*	-	0.405*	-
Pseudo-R^2	0.367	0.333	0.303	0.127	0.619	0.309
Number of observations	5402112	4519350	3732094	550467	3197800	154147
Sample	---------- Unbalanced ----------				------- Balanced -------	

Note: The constant terms are omitted in the table, but they can be obtained from the authors. *: Significance at a five percent level. The reference person is a 35-44 years old master educated woman working in the agriculture etc. sector as a researcher in the natural science (ISCO=21) at an establishment with 1-9 employees.

Appendix 3: Job mobility rates for employed HRST and selected subpopulations, 1988-97

Figure A1: The job-to-job inflow mobility rates, 1988-97. HRST employees. Pct.

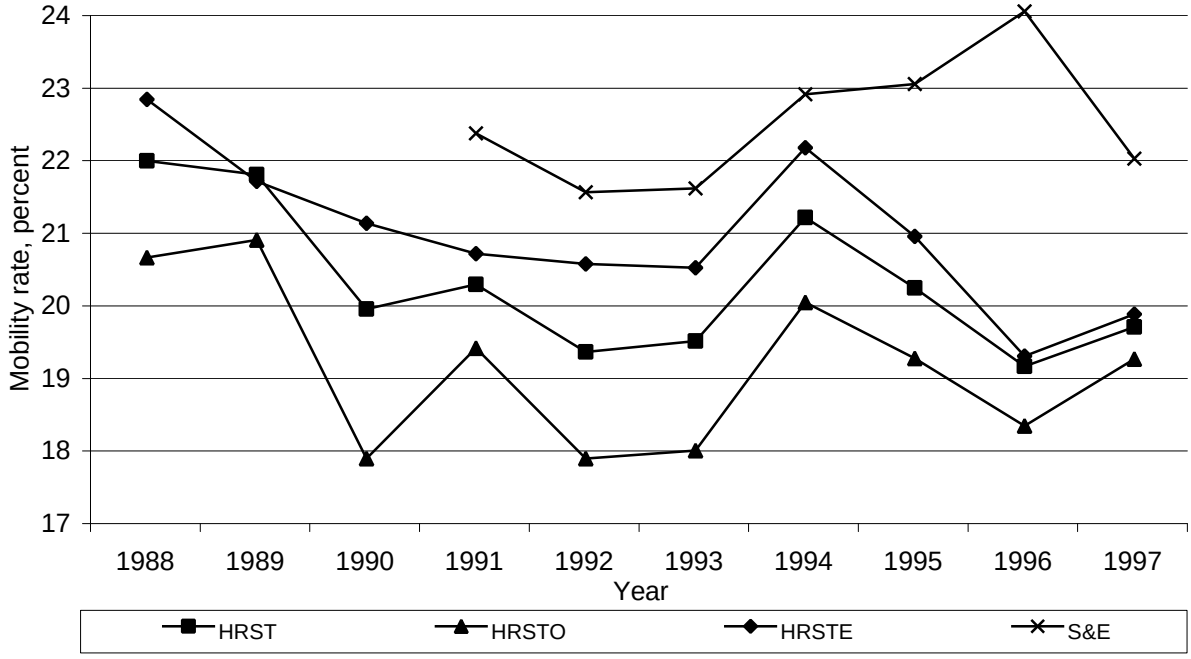
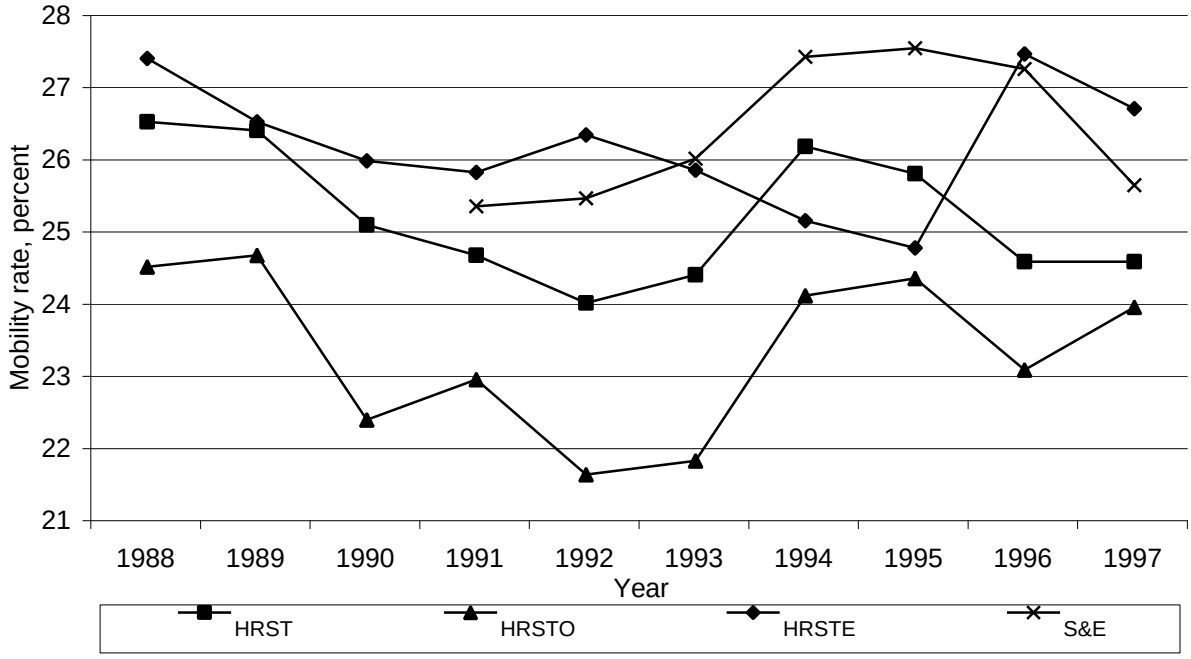


Figure A2: The overall inflow mobility rates, 1988-97. HRST employees. Pct.



Appendix 4: Job mobility rates for employees in the labour force, 1988-97

Figure A3: The job-to-job inflow mobility rates by sectors, 1988-97. All employees. Pct.

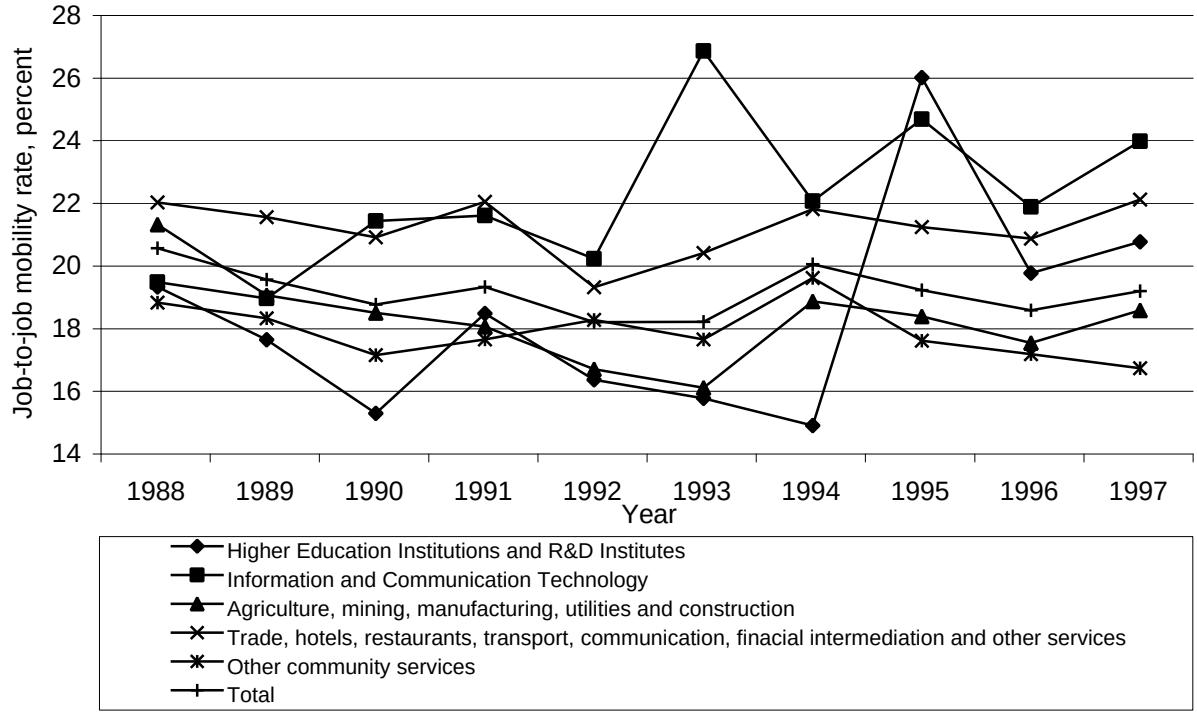
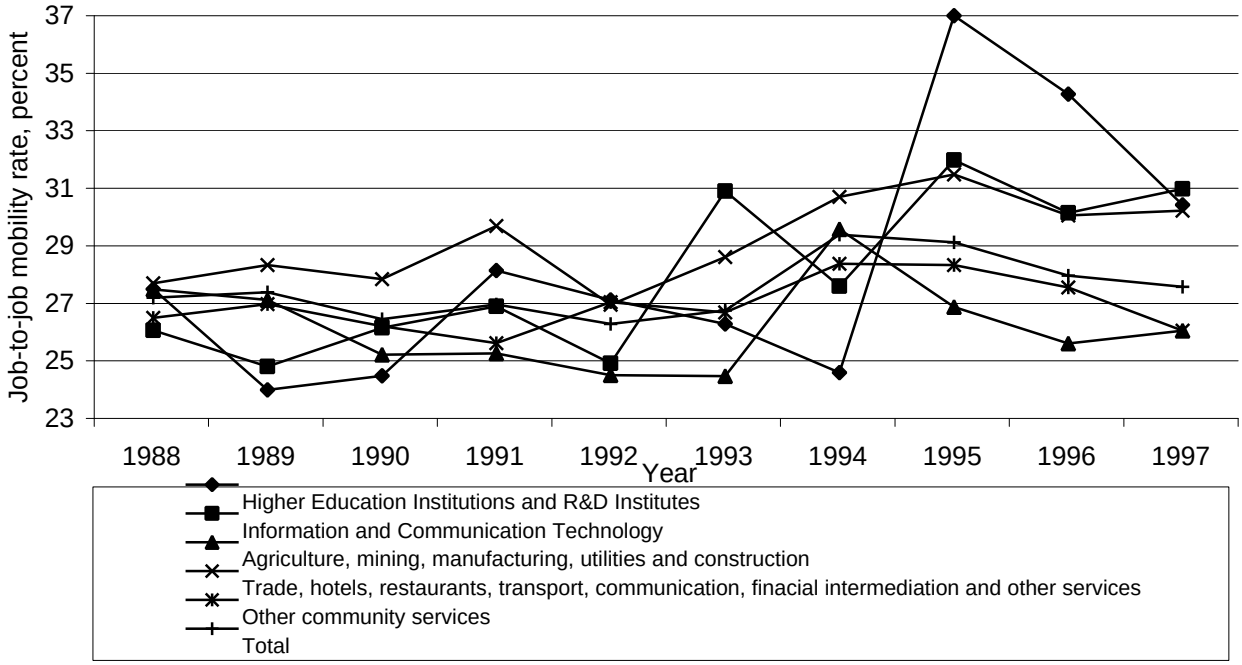


Figure A4: The overall inflow mobility rates by sectors, 1988-97. All employees. Pct.



Appendix 5: The HRST population in Denmark according to the Community Labour Force Survey, CLFS

Table A.4: The HRST population in Denmark in 1999 based on the CLFS, in thousands. Share of the total HRST in brackets and the male share in each subgroup in parenthesis

The HRST population		Education		
		3rd level education ISCED76={5,6,7}	Below 3rd level education ISCED76 < 5	Total
Occupation	Managers Professionals Technicians	529 [45] (47)	[redacted] 336 [28] (57)	865 [73] (51)
	Other occupations Unemployed or Inactive	321 [27] (56)	[redacted]	321 [27] (56)
Total		850 [72] (50)	336 [28] (57)	**1185** **[100] (52)**

Source: Eurostat (2001).

Table A.5: The S&E population in Denmark in 1997 based on the CLFS, in thousands. Share of the total S&E in brackets and the male share in each subgroup in parenthesis

The S&E population	Education		
	3rd level education ISCED76={5,6,7}	Below 3rd level education ISCED76 < 5	Total
Professionals	98 [85] (72)	15 [15] (89)	113 [100] (74)

Source: Laafia (2000).