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Knowledge spillovers – Mobility of highly educated workers within high technology sector in Finland

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KNOWLEDGE SPILLOVERS – MOBILITY OF HIGHLY EDUCATED WORKERS WITHIN HIGH TECHNOLOGY SECTOR IN FINLAND

Kirsi Mukkala
School of Business and Economics, University of Jyväskylä
Finland
kirsi.mukkala@econ.jyu.fi

Abstract: The economic development and technological progress of a region are highly dependent on the accumulation and diffusion of knowledge. There are numerous channels through which knowledge might be transmitted. In this study, it is assumed that the mobility of highly educated and innovative intensive workers between firms and regions has an important role in the diffusion of knowledge. Hence, this analysis concentrates on the regional job flows of individuals working in the high technology sector. The empirical analysis of the paper is based on data from the Finnish Longitudinal Census File. Data contain information on the individuals' economic activity, family and dwelling conditions, as well as the characteristics of their home regions. The decision to change the working region is modelled by the maximum likelihood estimation which employs cross-sectional binary logit model, based on logistic distribution. According to results the high technology sector and worker flows are strongly concentrated on urban regions in Finland. The individuals with a lot of human capital resources (high education and working experience of knowledge intensive sector) are willing to change their working region even if they already have a job in the non-urban region, which implies that those regions have difficulties to retain their high technology labour force. The highly educated high technology workers are sligthly more active in changing their working region than the others which contribute to the effective transfer of knowledge between firms and regions.

1. Introduction

The economic development and technological progress of a region are highly dependent on the accumulation and diffusion of knowledge, referring to a transformation towards knowledge-driven economies. In this respect, the knowledge intensive sectors in production and services have a considerable impact on the development of economies. The role of human capital stock as a prerequisite for regional growth and competitiviness has been emphasized in many studies (e.g. Barro and Sala-i-Martin 1991; Camagni 1995; Davelaar and Nijkamp 1997; Lucas 1988). An interesting aspect of this perspective is the geographic scope of knowledge spillovers.

Knowledge can be considered as a partially excludable and non-rivalrous good. Thus, it has some of the characteristics of public goods, which implies that it is subject to spillovers. There are numerous channels through which knowledge might be transmitted to firms. It may occur via e.g. publications and patent applications, inter-firm co-operation, interactive learning associated with buyer-supplier relationships, R&D collaborations and strategic partnering or via mobility of workers. Usually, the transmitted knowledge is mainly tacit, highly contextual and difficult to codify, and therefore more easily transferred through face-to-face contacts and personal relationships. Thus, the quality and availability of communication have a considerable impact on the efficiency of the transfer of ideas and knowledge. However, an important aspect of diffusion is not only the qualities of knowledge (e.g. whether it is tacit or easily imitated), but also the activity of regional labour market for the engineers, scientists and workers. (Almeida and Kogut 1999; Breschi and Lissoni 2000; Fischer and Varga 2003; OECD 2001.)

The growing importance of high technology sector has further intensified the role of human capital and most studies seem to be unanimous in concluding that knowledge spillovers are important, but they are also strongly bounded in space. According to one view, a region forms a social community or milieu that shares the knowledge and diffuses it. Alternatively, an individual worker embodies the relevant knowledge and diffuses it through an interactive and collective process within a web of personal and institutional connections. (Breschi and Lissoni 2000.)

A basic assumption is that a regional mobility of highly educated and innovative intensive workers between firms, organisations or institutions secures the diffusion and circulation of the knowledge that increases overall knowledge and innovation. In other words, by hiring a new worker, an employer will have access to the specific knowledge embodied in the worker and to the contacts (social capital) that she brings along (Breschi and Lissoni 2003). The knowledge of employees acts as a non-material input for firms. Research and development personnel, as well as skilled operative personnel, can be considered as a necessary input in the process of innovation. (Davelaar and Nijkamp 1997; Ritsilä and Ovaskainen 2001.) However, it depends e.g. upon each person's ability and opportunity to learn from the organisation in which he is employed prior to the move (duration of employment, education, position held in the organisation) and it is not an easy task to assess the impact and extent of knowledge transfer associated with experienced personnel. Moreover, the total quantity of information spillovers in the local economy depends both on the quantities of information which spill over in each individual information transfer and the frequency of these spillovers (Faggian and McCann 2004).

Migration plays an important role in the diffusion of knowledge between regions and can lead to significant changes in regional stocks of human capital. Many studies on migration behaviour have proven that the propensity to migrate increases with educational level (e.g. Antolin and Bover 1997; Molho 1987; Owen and Green 1992; Ritsilä and Ovaskainen 2001). The migration figures in Finland indicate that a positive net inflow of migrants, in particular the flow of highly educated migrants, is concentrated only on a few core areas, which raise the educational level of those regions, provide new ideas and encourage firms to invest in projects that embody new technologies. At the same time, the remote regions are losing their human capital, as the young and educated people move away to the central regions. (Kauhanen and Tervo 2002; Nijkamp and Poot 1997; Pekkala 2003; Ritsilä and Ovaskainen 2001.)

This study expects to offer new information on several fronts. As stressed in Finnish literature, migration plays a significant role in the spatial redistribution of human capital, intensified by the selective nature of migration process. However, rather little research has been carried out in order to evaluate the extent of labour mobility in determining the regional human capital stock and inter-regional knowledge spillovers. In this

study, the main emphasis is on the highly qualified employees, since they are the individuals who contribute the highest innovation potential. To evaluate the quality, frequency and geographical scope of the knowledge spillovers the following questions should be answered:

(1) How the highly educated high technology workers differ from the other workers with regard to their propensity to change the working region?

(2) From which regions they come and where they are going to?

The topic of this paper has been touched on in the study of Virtaharju (2001). He has analysed the mobility rates of workers over time (years 1987-1998) and between various sub-groups (based on the labour market status, sector and size of the workplace, age and educational level) in Finland. The job-to-job mobility is defined as a shift of workplace between the previous and present year, and the job-to-job inflow mobility rate is calculated as the number of employed movers between two consecutive years divided by the total number of employees employed both years. According to results the mobility of highly educated was highest in the ICT-sector compared with the other sectors[1] (the share of workers changing job inside the same firm was approximately 40 %). The general tendency is that the male mobility rate is equal to or higher than the female mobility rate, the mobility rate is highest among the youngest workers, and it increases with educational level and decreases with the size of the workplace.

This paper is structured as follows. Section 2 introduces the characteristics and regional distribution of workers in Finnish high technology sector. Section 3 consists of a description of the model and variables applied. This is followed by the presentation of results in section 4. Section 5 concludes the paper.

2. High technology workers in Finland

This descriptive analysis is based on data of the Finnish longitudinal census. It contains 7 % sample of individuals residing in Finland in 2001 (470 000 individuals). The census file is maintained and updated by Statistics Finland.

The definition of the working sector of an individual is based on the 5-digit level of standard industrial classification of the year 1995. The sub-sectors of high technology are represented in table 1. In this data, there are 14 574 workers in high technology sector in 2001 (10.6 % of all workers). The comparisons reveal that the high technology workers are generally younger than the workers in the other sectors. Their average age is 38.8 years and the share of workers aged less than thirty-five is 39.3 %. The same figures in the other sectors are 41.2 and 29.8 %, respectively. Due to the technical orientation of the sector the main part of high technology workers are men (70.7 %) and technically educated (51.1%).

The definition of the educational level follows the Finnish Standard Classification of Education (based on the year 2002). Higher education means at least the lowest level of tertiary education (education time about 13-14 year). This data for the year 2001 shows that the share of highly educated workers in high technology sector is 42.8 % whereas in the other sectors it is smaller, 34.0 %. The share of highly educated varies between the high technology sub-sectors (table 1). It reaches the highest level in research and development (66.7 %) and in computer and related activities (58.0 %). In each sub-sector, except for computer and related activities, the educational level is higher among the new workers who have moved from other regions (municipality of their workplace has changed from 1999 to 2001) than among the workers as a whole. The figures of the year 2001 indicate that the in-flow of new workers from the other regions has been larger in the sub-sectors with high level of education than in the others.

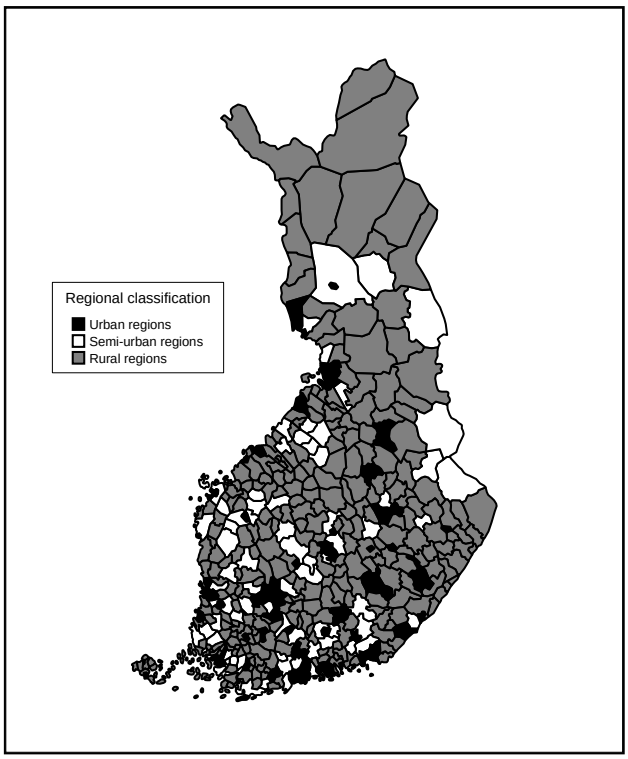
Table 1. Highly educated workers in high technology sub-sectors in 2001 based on data of the Finnish Longitudinal Census

	Number of workers	**Highly educated workers, %**	**New workers* from other regions, %**	**Highly educated new workers, %**
Manufacture of chemicals, chemical products and man-made fibres	1 307	**35,7**	9,3	**54,5**
Manufacture of machinery and equipment	4 178	**29,2**	12,6	**37,7**
Manufacture of office machinery and computers	50	**38,0**	8,0	**75,0**
Manufacture of other electrical machinery and apparatus	1 127	**29,3**	13,5	**38,8**
Manufacture of radio, television and communication equipment and apparatus	2 540	**55,4**	21,7	**64,9**
Manufacture of medical, precision and optical instruments, watches and clocks	840	**46,7**	17,7	**52,3**
Manufacture of motor-vehicles, trailers and semi-trailers	525	**17,9**	8,6	**31,1**
Manufacture and repair of railway and tramway locomotives and rolling stock, manufacture of aircraft and spacecraft	286	**21,7**	1,7	**40,0**
Computer and related activities	2 702	**58,0**	25,8	**57,8**
Research and development	1 019	**66,7**	12,7	**75,2**

* Workers who have changed their working region in 1999-2001.

The regional distribution of high technology workers is analysed by using three groups of municipalities. In the grouping of Statistics Finland, municipalities are divided by the proportion of the population living in localities and by the population of the largest locality into urban (62 % of population), densely populated or semi-urban (17 % of population) and rural municipalities (21 % of population)[2]. The classification is based on the definition of localities that is made every five years in connection with the population censuses and on the data thus obtained about the population living in localities. The latest grouping of municipalities is based on the data of the 2000 Population Census. The location of those region groups is represented by a map in figure 1.

Figure 1. Regional grouping of Finnish municipalities



The main part (about 82 %) of employees in the high technology sector is working in urban regions (table 2). The geographical concentration is even clearer when only the highly educated workers are concerned: approximately 90 % of them are locating in urban regions. The location pattern varies between different sub-sectors. Computer and related activities, manufacture of office machinery and computers, manufacture of medical, precision and optical instruments, watches and clocks, and manufacture of radio, television and communication equipment and apparatus are more concentrated on urban regions (more than 90 % of workers according to this data) than the other sub-sectors.

The worker flows in three region groups in 1999-2001 are also described in table 2. All high technology sector workers and highly educated high technology workers are represented separately. The third and fourth columns represent the regional distribution of new workers in high technology sector, in other words, in which regions they are working after the change of their working region. The last two columns refer to the regions of origin where the high technology employees were working before their move (in 1999).

The worker-flows in high technology sector are strongly concentrated on urban regions. About 88 % of those who changed their working region in 1999-2001 moved to urban regions and only one fifth of all new workers came from outside the urban regions. The same kind of development can also be seen with highly educated new workers. Only 7 % of them moved to the other than urban regions. The comparison with the other sectors reveals that the worker-flows in high technology sector are more concentrated on urban regions. Since, in the other sectors the urban regions received 72 % of new workers and the rest of them were equally distributed between the semi-urban and rural regions. In the other sectors the out-flow of workers from rural areas was rather intense, comprising 17 % of those who changed their working region.

The capital region is also represented in table 2 but due to the lack of information it indicates the individual's region of domicile instead of the working region. It shows that one third of workers in high technology sector and more than 40 % of highly educated workers in that sector are living in the capital region.

Thus, it is clear that the urban regions are the big winners in regard to human capital accumulation. This weakens the position of other regions which are losing their population, particularly, the highly educated workers. These loses are only partly compensated with the in-flow of new workers. Strong regional concentration of highly educated workers might be explained by their own preferences and also by the labour market factors, as the sub-sectors or certain tasks requiring high education are situated in the central regions.

Table 2. Regional distribution of workers in high technology sector (%) and their mobility in 1999-2001

	Number of workers (in 2001)		**Where the new workers move to, % (working region in 2001)**		**Where the new workers come from, % (working region in 1999)**	
	High tech	**High tech & high education**	**High tech**	**High tech & high education**	**High tech**	**High tech & high education**
Urban regions	81,9	89,7	88,1	92,8	81,9	85,8
Densely populated regions	10,7	6,3	5,9	4,4	10,9	9,2
Countryside	7,4	4,0	5,9	2,8	7,2	5,0
Capital region	*32,9*	*41,8*	*46,8*	*52,0*	*46,0*	*52,6*
Total number	14 574	6 237	1 279	684	1 279	684

Next, the high technology employees whose working region was changed from 1999 to 2001 are classified into three groups based on their working sector before the move (in 1999) (table 3). It is assumed that the knowledge is transferred most effectively by the individuals who move inside the high technology sector. More than half of all new employees from the other regions were working in the high technology sector already before their move and most of them represented the same sub-sector. Among the highly educated the regional moves within high technology sector are slightly more frequent, approximately 57 % of new workers were employed in high technology sector already before they changed their working region. The 'staying rate' in the same sub-sector varies a lot between different sub-sectors being highest in the manufacture of radio, television and communication equipment and apparatus, and computer and related activities. Thus, the knowledge spillovers are probably most effective in these sectors.

Table 3. In which sectors the new workers were employed before their move (in 1999)?

	High tech sector workers	Highly educated high tech sector workers
Same high tech sector, %	43,0	43,8
Other high tech sector, %	11,0	13,0
Other than high tech sector, %	46,0	43,2

3. Modelling and variables

3.1 Estimation method

Usually, the migration decision is based on the maximization of individuals' economic utility. Hence, migration takes place if the expected utility from relocating exceeds the economic utility from staying. In this study, the main topic of interest is not the decision to migrate but the decision to change the working region. However, the theory of utility maximization applies here as well.

Methodologically, the decision to change a job is modelled by the maximum likelihood estimation. It employs cross-sectional binary logit model, based on logistic distribution (see, Greene 1997). The dependent variable, move from one municipality to another, is analysed by the dummy variable which gets the value of one ($Y = 1$) if the individuals' municipality of working in 1999 is different from that of 2001, and otherwise it gets the value of zero ($Y = 0$). There is a set of factors that affect individual's decision. Those

independent variables are gathered in a vector *x*. The choice between the two alternatives is based on utility maximization. Thus, the ith individual utility of the choice j is

$$U_{ij} = \beta_j' x_i + \varepsilon_{ij} \text{ for } j = 0, 1 \qquad (1)$$

where β's are unknown parameter vectors. The probabilities for the choices of an individual are given by

$$\text{Prob}(Y = 1) = F(\beta' x) \text{ and} \qquad (2)$$

$$\text{Prob}(Y = 0) = 1 - F(\beta' x) \qquad (3)$$

or

$$\text{Prob}(Y = 1) = \frac{e^{\beta' x}}{1 + e^{\beta' x}} \text{ and} \qquad (2')$$

$$\text{Prob}(Y = 0) = \frac{1}{1 + e^{\beta' x}}. \qquad (3')$$

For the estimation of the binary choice model a likelihood function is required. That log-likelihood function for a sample of *n* observations is thus,

$$\ln L = \sum_{i=1}^{n} \left[y_i \ln \Pr ob(Y_i = 1) + (1 - y_i) \ln \Pr ob(Y_i = 0) \right] \quad (4)$$

It can be shown that the Hessian is always negative definite, so the log-likelihood function is globally concave. Newton's method can be applied for maximizing the function.

3.2 Explanatory variables used

The Finnish longitudinal census data provide information on individuals' personal and household characteristics as well as the regional characteristics of their home districts. The sample used for this modelling was restricted to individuals aged 20 to 63. Less than twenty years old workers were dropped from the analysis due to the importance of high education in this study. It is assumed that individuals aged twenty or more have theoretical possibilities to have acquired higher education.

The results of several studies on migration behaviour show that the likelihood of migration increases with the level of education. The extensive mobility of the highly educated is related to personal factors like career orientation, psychological readiness to move, social needs, knowledge about personal opportunities, sufficient economic potential to move, opportunities to profit economically and narrowness of relevant job markets (Ritsilä and Ovaskainen 2001). Besides the education, there are some other commonly recognized individual specific factors that affect migration (labour market status, age, number of children, type of dwelling occupied, etc.).

The explanatory variables used in this study can be grouped into personal characteristics (age, sex, educational level, home ownership), family characteristics (marital status, number of children aged less than eighteen), working life characteristics (technical education, income level) and regional characteristics (type of the working region, commuting behaviour) (table 4).

Like the mean values indicate a half of workers in high technology sector are technically educated whereas in the other sectors only one fifth of workers have technical education. The technical education is more usual among men than women and that explains partly the low share of women in high technology sector. The workers aged between 30-45 form the biggest group (47 %) in high technology sector and the share of older workers is below 30 %. On the other hand, in the other sectors the biggest age group consists of old workers (over 45 years). The income level is clearly higher in high technology sector than in the other sectors and it increases with education. The means of regional variables show that high technology sector and particularly the jobs requiring higher education are much more concentrated on urban region than the other sectors' jobs. Also, the commuting is more frequent among the high technology workers than among the others. This might be explained, at least partly, by the sector's strong concentration on the capital area where the commuting is usual.

Table 4. Descriptive statistics of variables applied: definitions and sample means

Variable	Definition	Mean		
Personal characteristics		*Non-high tech workers*	*High tech workers*	*Highly educated high tech sector workers*
YOUNG	A dummy variable that is assigned a value of 1 if one is younger than age 30 and 0 otherwise	0,25	0,24	0,19
MIDAGE	A dummy variable that is assigned a value of 1 if one's age is between 30 and 45 years and 0 otherwise	0,35	0,47	0,58
FEMALE	A dummy variable that is assigned a value of 1 if one is female and 0 if male	0,51	0,30	0,32
HOMEOWN	A dummy variable that is assigned a value of 1 if one owns a house or owns shares in a housing corporation and 0 otherwise	0,67	0,69	0,71
Family characteristics				
MARRIED	A dummy variable that is assigned a value of 1 if one is married and 0 otherwise	0,49	0,52	0,58
CHILD	A dummy variable that is assigned a value of 1 if one's children are younger than 18 years and 0 otherwise	0,38	0,42	0,48
Working life characteristics				
TECHNICAL	A dummy variable that is assigned a value of 1 if one have a technical education and 0 otherwise	0,20	0,49	0,51
LOWINC	A dummy variable that is assigned a value of 1 if one's income subject to state taxation is below 21 100 euros (= median of all sample workers) and 0 otherwise	0,68	0,28	0,16
MIDINC	A dummy variable that is assigned a value of 1 if one's income subject to state taxation is between 21 100 and 32 400 euros (= median of highly educated high tech workers) and 0 otherwise	0,21	0,42	0,34
Regional variables				
COMMUTER	A dummy variable that is assigned a value of 1 if one's working region and residing region differs (commuter) and 0 otherwise	0,30	0,42	0,46
NONURBAN	A dummy variable that is assigned a value of 1 if the region of origin not belong to the urban areas and 0 otherwise	0,31	0,20	0,12

4. Results based on interactive binary logit model

A special interest of this binary logit modelling is to examine how the highly educated high technology workers differ from the others regarding the propensity to change the working region. In this model the dependent variable indicates whether the working region of an individual has changed between the years 1999 and 2001. The sample consists of individuals aged 20-63 in 1999 who belonged to the labour force in 1999-2001 (number of observations is 126 037).

First, to test whether there is a "universal" difference in the probabilities of changing the working region between the two groups, a dummy, which obtains the value one if an individual is highly educated and working in the high technology sector, is included in the equation. Secondly, to test whether the explanatory variables have similar effects on the probability of changing the working region among the highly educated high technology workers in contrast to the others, interaction variables are also included in the equation. They are formed by multiplying each explanatory variable with the dummy denoting the highly educated high technology workers. Whether the coefficients of the interaction dummies are statistically significant or not can be tested by the conventional test based on the Wald statistic.

Table 5 shows the estimation results. The first part in table 5 reports estimated coefficients, statistical significances and standard errors for the first group which consists of highly educated individuals working in the high technology sector. The second part shows the equivalent results for the reference group consisting of a sample of all other individuals belonging to the labour force. The third part reports the results for the interaction variables through which the differences between the two groups can be evaluated. Adding of the estimated coefficients in parts two and three also gives the coefficients estimated for the first group.

The estimated coefficient of the interaction dummy indicates that highly educated high technology workers who embody a lot of human capital are sligthly more active in changing their working region than the others (at 10 % significance level) which implies that knowledge is transmitted between firms and regions. With regard to the effect of

technical education, the coefficient is negative in both groups but it has not a statistically significant effect on the highly educated high technology sector workers.

The age effects were taken into account in the model by two dummies, one denoting whether a person is below age thirty and the other denoting whether a person is between ages 30-45. The results suggest that the individuals belonging to these age groups have higher propensity to change their working region in both groups. The active mobility of young people compared to the older ones is a very typical result and reasons for that are, e.g. a shorter expected working period over which to realize the advantages of the job change and the increased importance of job security, family ties and familiar living environment. However, the quality level of knowledge of young workers can be lower than that of older ones due to their short working experience. Thus, it could be assumed that from the efficiency point of view the older workers form the most valuable group and their active mobility would be favourable for the knowledge spillovers as well. Even if the age effect is clearly positive in both groups, the interaction variable reveals that the propensity of changing the working region is lower among the young highly educated workers in high technology sector compared to the others. This might imply that the young employees in high technology sector are more satisfied with their current job than the young working in the other sectors.

The personal factors like being a woman or being married decrease the willingness to change the working region among the other workers but have not effect among the highly educated high technology workers. The differences between the two groups are statistically significant at 10 % level. What is interesting in these results is the effect of children aged less than eighteen. The logical assumption is that having children decreases the propensity to change the working region among all workers, particularly if the region of domicile changes at the same time. The migration with the whole family including school-aged children involves both material and immaterial costs, e.g. moving costs and change of the living environment. However, this assumption seems to apply only to the highly educated high technology workers whereas the effect is not statistically significant among the other sectors' workers. Owning a home has a negative effect in both groups. It is evident from the other studies as well that owning a home ties a person strongly to the region. The economical reason might be the main explanation for this together with the willingness to stay in the familiar living environment. However,

the change of working region does not necessarily mean that also the region of domicile changes.

The impact of income level was examined by using two dummies. The one denotes workers with the income below the median level of all workers in the sample, and the other make the difference between workers belonging to the mid-level income group and the others. The mid-level income in this model is defined so that it exceeds the median level of the whole sample but it is below the median level of highly educated high technology workers. Low income level has not significant effect on workers' propensity to change the working region whereas the mid-income level decreases it in both groups. Probably, the change of working region may not improve (enough) the economic position of mid-income workers and thus, it is not beneficial or cost-effective to change the working region. The differences between the groups are not statistically significant.

If a person is commuting between the region of domicile and that of working, the propensity to change the working region increases. The commuting is very popular among the highly educated high technology workers (nearly 50 % of workers are commuters), probably due to their concentration on the capital region where the distances are short. The propensity to change the working region is lower among the highly educated commuters of high technology sector but the coefficient is strongly positive and significant in both groups. A probable explanation could be that commuters have found a pleasant place of living and they want to stay and find a job in that region. This implies that an attractive environment of living has also an important role in the competitiveness of regions.

The high technology sector is strongly concentrated on urban regions and only one fifth of jobs are situated outside those regions. These results show that if an individual is working outside the urban areas it increases her willingness to change the working region. The propensity is still stronger if only the highly educated high technology workers are analysed. Thus, the individuals with a lot of human capital resources (high education and working experience of knowledge intensive sector) are willing to change their working region even if they already have a job in the non-urban region. This implies that the non-urban regions have difficulties to retain their existing high technology labour force. Probable explanations for this could be that the urban regions

can provide better possibilities to make progress in career and to keep up with the rapid development of the high technology sector. Also the uncertainty of the permanence of the current job in non-urban regions can increase the willingness to move. These results support the view that human capital continues to concentrate on central areas.

Table 5. Binary logit model for the likelihood of changing the working region (individuals aged from 20 to 63 who belonged to the labour force in 1999-2001, n=126 037)

	Highly educated workers in high tech sector	**No highly educated or high tech workers**	**Interaction term included**
	Coefficient	***Coefficient***	***Coefficient***
Constant	-2,082*** (0,143)	-2,360*** (0,034)	0,278° (0,147)
YOUNG	0,896*** (0,131)	1,226*** (0,028)	-0,330** (0,134))
MIDAGE	0,600*** (0,109)	0,568*** (0,024)	0,032 (0,111)
FEMALE	-0,100 (0,093)	-0,265*** (0,020)	0,164° (0,095)
MARRIED	0,103 (0,090)	-0,068*** (0,021)	0,171° (0,093)
CHILD	-0,224** (0,091)	-0,031 (0,021)	-0,193* (0,093)
HOMEOWN	-0,266*** (0,082)	-0,374*** (0,020)	0,109 (0,085)
TECHNICAL	-0,039 (0,084)	-0,129*** (0,022)	0,089 (0,086)
LOWINC	0,135 (0,114)	-0,007 (0,026)	0,142 (0,117)
MIDINC	-0,143° (0,086)	-0,256*** (0,026)	0,114 (0,090)
COMMUTER	0,723*** (0,073)	1,206*** (0,018)	-0,483*** (0,075)
NONURBAN	0,454*** (0,105)	0,171*** (0,020)	0,283** (0,106)
Number of workers	5 158	120 879	
Number of movers	1 006	16 689	

Notes: *** statistically significant at the 0.001 level
** statistically significant at the 0.01 level
* statistically significant at the 0.05 level
° statistically significant at the 0.10 level
Standard errors are in parenthesis. Interaction variables are formed by multiplying all explanatory variables by the dummy denoting highly educated high tech sector workers.

5. Conclusions

The knowledge and human capital have an important role in high technology sector. In this study it is assumed that the highly educated high technology sector workers possess a lot of human capital resources. According to the data, in 2001 about 43 % of high technology workers were highly educated which was almost 10 % more than in the other sectors. The share of highly educated individuals varies between the high technology sub-sectors, and reached 67 % in research and development.

The high technology sector is strongly concentrated on urban regions, e.g. nearly 97 % of workers in computer and related activities are working in urban regions. This refers to the strong accumulation of human capital which has a considerable impact on the

local collective learning process, enhancing the productivity of firms and improving the external image and attraction of the region itself. Human capital is effectively created by people who also have possibilities to use their ideas in their own environment and to apply them to productive activities (Okko 2000). Moreover, the geographical proximity facilitates the cooperation and the creation of informal contacts between local actors. Hence, it increases the speed of information flows and improves the possibilities of firms to take full advantage of externalities generated through untraded interdependencies and linkages. (Acs 2002; Camagni 1995; Hansen 1992.)

In this paper, the regional transfer of knowledge in the high technology sector was analysed by paying a special attention to the changes of individual's working region. The regional worker flows are strongly concentrated on urban regions. Only 10 % of worker flows of high technology sector in 1999-2001 were directed to the semi-urban or rural areas and among the highly educated workers the share was still lower. This implies that only some regions benefit from the knowledge embodied in new workers and the urban regions are the big winners.

New workers from the other regions can bring along very sector specific (e.g. technical) knowledge or they can possess more general-type of knowledge and new ideas for example about the needs of potential customers, etc. The former is most effectively transmitted via new workers who are working in high technology sector already before their move. In this data, their share was approximately 55 % in 2001 which corresponds with the average level of all workers moving within the same sectors (see Virtaharju 2001).

The empirical results of interactive binary logit model indicate that the propensity to change the working region is slightly stronger among the highly educated high technology sector workers compared to the other workers which contribute to the effective transfer of knowledge between firms and regions. The workers aged less than thirty are the most active in changing their working region. However, from the point of view of effective knowledge spillovers the young workers are not necessarily those who possess most the human capital due to their short working experience. The estimation results support also the view that human capital tends to accumulate to the urban regions. Regional mobility of individuals working outside the urban areas is stronger than among the urban workers, and this behaviour is even emphasized among the highly educated

high technology workers. It can be assumed that these worker flows from semi-urban and rural areas are mainly directed to urban regions.

The knowledge spillovers are topical but challenging theme of research. This paper provides one aspect of the topic and these mainly descriptive results provide a base for the continuation of the research theme.

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Notes

[1]The following sectors were analysed: 1) ICT; 2) primary production, manufacturing, energy production and construction; 3) trade, transport and business services; 4) education and research; and 5) public and private services.

[2]*Urban municipalities* are those municipalities in which at least 90 % of the population lives in urban settlements, or in which the population of the largest urban settlement is at least 15 000. *Semi-urban municipalities* are municipalities in which at least 60 % but less than 90 % of the population lives in urban settlements, and in which the population of the largest urban settlement is at least 4 000 but less than 15 000. *Rural municipalities* are those municipalities in which less than 60 % of the population lives in urban settlements, and in which the population of the largest urban settlement is less than 15 000, as well as those municipalities in which at least 60 % but less than 90 % of the population lives in urban settlements, and in which the population of the largest urban settlement is less than 4 000.

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