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Career Networks and Job Matching - Evidence on the Microeconomic Foundations of Human Capital Externalities

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Abstract

Inspired by the literature on the importance of local career networks for the quality of labor market matches we investigate whether human capital externalities arise from higher job matching efficiency in skilled regions. Using two samples of highly qualified workers in Germany, we find that increasing the regional share of highly qualified workers by one standard deviation raises wages on the incidence of job change by up to three percent, pointing to the importance of improved job matching opportunities in human capital rich regions as a microeconomic source of human capital externalities. Evidence on regional differences in job change behavior suggests that human capital networks enable young workers to change jobs more easily and to thereby increase matching efficiency, which in turn reduces the overall number of job changes needed until an efficient match is reached. Benefits from improved matching opportunities predominantly arise from human capital networks enabling workers in skilled regions to change jobs within an industry and, thus, to capitalize on their industry-specific human capital.

Keywords: Human Capital Externalities, Job Matching, Agglomeration Economies
JEL Categories: D62, J24, J31, R11

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I. Introduction – The Microeconomics of Human Capital Externalities

> *"Put differently, it is now time to [...] attempt to understand precisely how human capital externalities percolate. [...] Most mechanisms generating local increasing returns to scale can be enriched to take human capital into account and generate external effects of human capital".*
>
> Gilles Duranton (2006: 35)

The idea that aggregate human capital matters for productivity and growth, which has gained prominence with the seminal contribution by Lucas (1988), has over time been established as one of the empirical regularities in economics. While early macroeconomic studies show that economic growth increases with national average levels of education, more recent investigations on the matter have predominantly come from urban and regional economics. In this branch, empirical studies by Rauch (1993), Moretti (2004b), and Rosenthal/Strange (2008) provide robust evidence that aggregate regional education positively influences individual productivity and wages.[1]

Despite providing compelling evidence that regional human capital contributes to higher individual wages, none of the regional studies explicitly addresses the microeconomic mechanisms through which productivity enhancing effects from aggregate education come about.[2] This striking neglect can only be understood in historical perspective, i.e. when taking into account that from Marshall (1890) onwards external effects from aggregate education have routinely been assigned to spillovers of technological knowledge. Thus, in line with the notion that "the mysteries of the trade become no mysteries but are, as it were, in the air" (Marshall 1890: 271), a number of microeconomic papers have modeled the intensity of knowledge exchange as a function of local human capital (see Jovanovic/Rob 1989, Jovanovic/Nyarko 1995, and Black/Henderson 1999). Based on the prominence of the concept of knowledge spillovers, numerous empirical papers have investigated the importance of spatial proximity of human capital for regional innovation and growth. For a survey of this literature we refer the reader to Audretsch/Feldman (2004).

Without denying the importance of spillovers of technological knowledge as a source of human capital externalities, Gilles Duranton emphasizes in the opening quote that there might be more to human capital externalities and in this respect points to the richness of microeconomic mechanisms of agglomeration as a source of inspiration.

[1] The relationship between aggregate human capital and employment growth has been investigated e.g. by Simon/Nardinelli (2002) and Glaeser/Shapiro (2003). For reasons of brevity we refer the reader to Davies (2002) and Moretti (2004a), who survey the empirical literature on human capital externalities.
[2] Although human capital externalities are likely to also emerge as non-market externalities like reduced crime, or improved health or voting behavior, in what follows we restrict ourselves to a discussion of the microeconomic sources of market externalities and their relative importance.

Since the influential contribution by Duranton/Puga (2004), such microeconomic sources of agglomeration are usually categorized along the lines of sharing, matching, and learning, as core mechanisms through which increasing returns to scale from agglomeration contribute to higher wages in urban areas. Theories relying on sharing mechanisms suggest that firms in agglomerated areas benefit from sharing larger local markets with suppliers and customers alike, which in turn allows them to economize on transport costs and, hence, be more productive.[3] Theories of matching, in contrast, model benefits from agglomeration as being rooted in improved matching opportunities between workers and firms in dense urban areas (Kim 1990, Helsley/Strange 1990). Based on this taxonomy a number of studies have aimed to disentangle the sources of agglomeration economies as determinants of regional wages (see e.g. Glaeser/Maré 2001, Yankow 2006, and Wheeler 2006). In contrast, no such attempt has been made with respect to human capital, i.e. apart from evidence on the existence of localized knowledge spillovers not much is known about the mechanisms through which human capital externalities emerge.[4] This lack of knowledge about the microeconomic foundations of human capital externalities is startling since benefits from human capital externalities can, in principle, rest on a rich subset of microeconomic mechanisms similar to those underlying agglomeration externalities, i.e. on improved opportunities for learning, sharing, and matching.

Recognizing the lack of research on the microeconomic foundations of human capital externalities this paper investigates the role of improved matching opportunities arising from higher levels of aggregate education. Closely related to the literature on knowledge spillovers, the idea is that higher levels of education enhance the flow of information on job and career opportunities and thereby improve the quality of labor market matches in human capital rich regions. The fundamental difference between the literature on knowledge spillovers and the idea pursued here is that while the former literature regards knowledge as being of a purely technological nature, i.e. to entail information about products and process of production, we investigate whether increased levels of human capital carry information about vacancies, jobs, and careers, i.e. about efficient future matches between workers and firms. The idea that higher levels of overall education facilitate the flow of labor market information is intimately linked to the notion of career networks. Thus, a large body of sociological literature starting with Fischer (1982) has emphasized the importance of individual education for the size of social networks and therefore for access to informal information. This literature consistently finds that "the more educated people are, the

[3] New Economic Geography models are the most prominent type of models in this category. See Ottaviano/Thisse (2004) for an overview.
[4] See Halfdanarson/Heuermann/Suedekum (2008) for a comparison of the empirical literatures on the urban wage premium and on human capital externalities.

larger their personal network" (Grossetti 2007: 397). This finding implies that the size of networks not only depends on a worker's own human capital. In fact, the range of direct and indirect contacts within networks and thereby the amount of information accessible to an agent crucially depends on the surrounding overall level of education. Thus, human capital externalities may arise not only from the diffusion of technological knowledge between agents, but also from the transmission of information on job market opportunities and career perspectives, which over time leads to more efficient job matches.

The insight that career networks matter for the incidence of job changes and for the quality of job matches is rooted in the influential contribution by Granovetter (1974), who shows that more than fifty percent of job changers have found their job through personal contacts. Subsequent research on the structure of career networks has shown that they typically exhibit two properties, which are important for our own study. First, as shown by Boorman (1975), Granovetter (1983), and Podolny/Baron (1997), career networks transmit information most efficiently if they consist of many 'weak' ties, i.e. if a large number of individuals are loosely connected to each other. Such networks structures are contrasted to those made up by a small number of strong ties, e.g. close friends and kinship. Second, efficient career networks are characterized by a pronounced local dimension. In fact, models from information science (Cowan/Jonard 2004) and epidemiology (Jeger et al. 2007) show that information is transmitted most efficiently in networks exhibiting distinct small world structures, meaning that about ninety percent of contacts are regionalized, while the rest are of a long-distance nature. Accordingly, Casper/Murray (2005) provide evidence on the regionalization of information flows by showing that career paths of highly qualified workers within biotechnology clusters in Cambridge, UK, and in Munich, Germany, are shaped through participation in strongly localized career networks.

In sum, our study sets out from the idea that regional human capital endowments shape the size of local career networks and thereby determine the amount of information available to workers about job and career opportunities. The availability of such information in turn influences the efficiency of job matches within a local labor market. Theoretically, differences in local matching efficiency should be reflected in wage gains incurred by job changers, and in the job change behavior of workers over their life cycle. Concretely, workers who have access to larger career networks in skilled regions are more likely to change jobs early in life since knowledge on job opportunities allows them to earn higher wages by changing to a job where they can be more productive. Consequently, given their knowledge about efficient job matches, they can be expected to incur larger wage gains on the incidence of job

changes than workers in regions with low human capital endowments, who have less access to information on prospective career options. In general, workers 'shop between jobs' until they have found an efficient job match (Mincer/Jovanovic 1981, Farber 1999). Therefore, since workers in skilled regions find efficient job matches earlier in life, their propensity to change jobs should decrease faster than the propensity of workers in unskilled regions.

Putting this matching concept of human capital externalities to the test, we examine whether we can find empirical support for the two hypotheses arising from theory. First, with the existence of matching externalities, we expect to find workers in human capital rich regions to incur larger wage gains when changing jobs than workers in unskilled regions. Secondly, we expect to find workers in human capital rich regions to be more likely to change jobs earlier in life, but to display a smaller overall number of job changes. Using two panels of highly qualified workers, we first estimate Mincerian wage equations in order to investigate whether wage gains incurred by job changers are positively influenced by the regional level of human capital. Addressing the second hypothesis, we analyze whether regional human capital endowments increase the probability of a job change early in a worker's life, while depressing the overall number of job changes over the life cycle.

Our findings suggest that improved matching opportunities in skilled regions are of importance as a microeconomic source of human capital externalities. We find that an increase in the regional share of human capital by one standard deviation is associated with between-job wage growth of about two to three percent. Furthermore, an increase in the regional share of human capital by one standard deviation increases the annual probability of a job change early in life by up to .5 percent. Conversely, the total number of job moves is significantly and negatively related to the regional level of human capital. These findings together provide strong evidence that job matching efficiency is higher in human capital rich regions. Differentiating our results by types of job change, i.e. whether job changes occur within or between industries, we gain insight into the information content of career networks. Thus, we find that workers in human capital rich regions are about fifty percent more likely to change jobs within an industry rather than changing into a different sector. In addition, wage effects from aggregate human capital are about ten times larger for workers changing jobs within an industry compared to changers to other sectors. These findings suggest that the bulk of benefits from career networks arise because such networks allow young workers to obtain information on career options within industries and thereby to capitalize on their industry-specific human capital acquired earlier in life.

II. Social Networks and Job Matching: Literature Review and Econometric Approach

II.1. Local Career Networks and Job Matching Opportunities: Assumptions

In order for regional aggregate education to have an impact on the quality of labor market matching through more efficient information flows in local career networks, three premises have to be met. We briefly outline the rationale behind each of these premises and present empirical evidence on the extent to which they apply.

First and most crucial, our investigation hinges on the assumption that the quality of labor market matches is positively influenced by the existence and, more specifically, the size of career networks. Implicitly, such networks are assumed to reduce information gaps by providing informal information to workers and firms about unobservable characteristics of the other party (Jovanovic 1979). The intuition that career networks improve the quality of job matches has inspired a voluminous empirical literature in economics and sociology which is surveyed in Ioannides/Loury (2004). While we are not aware of a theoretical model that relates job matching quality directly to network size, recent theoretical contributions by Calvo-Armegnol/Jackson (2004, 2007) suggest that the accessibility of information on job opportunities increases with the size of career networks. Despite the lack of theoretical models, empirical studies support the idea that larger career networks transmit labor market information more efficiently and thereby increase matching efficiency in the labor market. Investigating the impact and structure of informal networks of Mexican immigrants, Munshi (2003) shows that workers in exogenously larger networks earn significantly higher wages, indicating higher productivity through more efficient job matches. Similarly, Datcher (1983) and Simon/Warner (1992) both show that in the face of difficult-to-observe job features, acquiring information about job characteristics through informal contacts significantly reduces the probability of a worker to quit a job later on.

Secondly, for human capital externalities to arise through improved matching opportunities it has to be the case that the size and with it the information content of career networks depend on aggregate human capital. Framed differently, our analysis rests on the idea that information on career options diffuses more rapidly and more effectively with higher regional levels of education. Theoretical models of the intensity of knowledge diffusion as a function of aggregate education have predominantly been developed in the economic literature on the transmission of

knowledge (Jovanovic/Nyarko 1995).[5] Evidence on the matter has, in turn, predominantly come from sociological studies. These studies, which we briefly touched upon above, provide evidence that the number of social contacts increase with individual education. Since, logically, the amount of information an individual has access to through second or third order ties increases with the level of education of other members in the network, the size and the range of career networks can reasonably be assumed to increase with aggregate average education.

Thirdly, for regional wage differentials to be caused by varying levels of matching efficiency, career networks have to exhibit a strong local dimension. The theoretical insight that information diffuses most efficiently in networks exhibiting small world properties (Watts/Strogatz 1998, Cowan/Jonard 2004) is confirmed by a number of studies in economics and sociology. To date, Bayer/Ross/Topa (2008) provide the most sophisticated study on the geographical scope of career networks. Controlling for reverse causality and sorting effects, the authors provide robust evidence that individual career perspectives and wages are shaped through social interactions between workers within the same block of residence. Their study is complemented by a broad literature showing that face-to-face communication and peer effects within local environments enhance the diffusion of knowledge on job perspectives (Cutler/Glaeser 1997), entrepreneurial opportunities (Acs/Armington 2004), and innovation (Jaffe/Trajtenberg/Henderson 1993).[6] The local nature of career networks is confirmed by numerous case studies. For instance, Combes/Linnemer/Visser (2008) show that personal networks, which are of prime importance for candidates to be successful in the centralized hiring procedure of economics professors in France, are of a strong local nature, i.e. are usually located within economics departments.

II.2. Identifying Matching Externalities: Two Approaches

Our identification strategy rests on two econometric approaches which correspond to the two hypotheses developed above. First, we analyze whether wage gains incurred by job changers increase with local aggregate education. Second, we examine whether workers in skilled regions display a higher propensity to change jobs earlier in life, while exhibiting a lower overall number of job changes when exiting the labor market. We take positive evidence on both hypotheses as indication for the existence of matching externalities arising from aggregate levels of human capital.

[5] Word-of-mouth models, e.g. Ellison/Fudenberg (1995), are a class of social learning models which also provide valuable insight into processes of knowledge diffusion (see Sobel 2000 for a survey). The problem with these models with respect to our case is that they do not include individual or aggregate education as a parameter determining the speed or the structure of information flows.

[6] See Brock and Durlauf (2001) for a comprehensive survey of the literature on social interaction.

Both hypotheses have their roots in the literature on agglomeration externalities, which posits that higher urban wages arise from improved matching opportunities in cities, made possible by a large number of workers and firms (Helsley/Strange 1990). Showing that wage gains of job changers are substantially larger in cities than in the countryside, Glaeser/Maré (2001) are the first to present empirical evidence for improved matching opportunities in cities as an explanation for higher urban wages. While their results are confirmed by Wheeler (2006), Yankow (2006) attributes the bulk of wage adjustments after job moves to wage growth effects, and thus to improved opportunities in cities to acquire productivity enhancing knowledge.

Analyzing regional differences in the patterns of job change, Bleakley/Lin (2007) find regional economic density to have a negative impact on the frequency of intra-regional job change for all but young workers. They interpret this finding as evidence that young workers in cities change jobs more often up to a point when they have found an optimal match within which they stay thereafter. Similar results with respect to the incidence of industry change are obtained by Freedman (2008), who shows that the probability of intra-industry change as compared to inter-industry job change is higher in agglomerated areas. Wheeler (2008) confirms these findings, but adds that the impact of agglomeration on job changes decreases with the number of prior job change and eventually becomes negative after the fourth move.

While both types of studies provide evidence for the occurrence of more efficient job matches in cities, one may contest that improved opportunities for labor market matching are caused by urban density alone. In fact, the close correlation between agglomeration and aggregate education leaves room for human capital externalities as an explanation for a higher quality of job matches in cities. In fact, since workers and firms usually lack information about the respective other (Jovanovic 1979), the availability of knowledge about potentially efficient matches is likely to be at least as important for matching efficiency as the sheer availability of jobs and workers. In this respect, career networks are of vital importance for efficient job matches to occur since they not only transmit information about jobs and workers available, but also reduce information asymmetries on unobservable characteristics of both parties.

With this consideration in mind we analyze whether aggregate human capital levels improve matching efficiency in regional labor markets. Doing so, we rely on the identification approaches suggested in the literature on agglomeration externalities.

Addressing the first hypothesis, we examine whether wage increases incurred on the incidence of job change depend on the regional level of education. We therefore

estimate Mincerian wage equations augmented by indicators for job change and regional human capital endowments, as well as interactions thereof.

$$w_{i,r,t} = \sum_{k=1}^{K} X_{k,i,t}\beta_k + \sum_{m=1}^{M} Z_{m,r,t}\gamma_m + \delta_1 M_{i,t} + \delta_2 HC_{r,t} + \delta_3 M_{i,t} \times HC_{r,t} + \phi_r + \phi_t + \varepsilon_{i,r,t} \quad (1)$$

More specifically, we estimate wage w of individual *i* at time *t* in region *r* as a function of *k* individual characteristics X_k, a number of *m* regional characteristics Z_m, the incidence of a job move M at time *t*, the share of highly qualified workers $HC_{r,t}$ in region *r* at time *t*, as well as the interaction between the latter two. Additionally, we control for region and time fixed effects. Our prime parameter of interest is δ_3, which measures the extent to which wage gains incurred by job changers depend on the regional share of highly qualified workers. We interpret a positive parameter δ_3 as indication that regional aggregate education increases the quality of job matches.

Our second hypothesis states that with the existence of matching externalities from education the probability of a job change should be positively influenced by regional human capital endowments. This relationship should weaken with an increasing number of prior job changes. Investigating this issue we estimate equation (2),

$$\Delta J_{i,r,t} = \sum_{k=1}^{K} X_{k,i,t}\theta_k + \sum_{m=1}^{M} Z_{m,r,t}\vartheta_m + \tau HC_{r,t} + \phi_r + \phi_t + \varepsilon_{i,r,t} \quad (2)$$

which expresses the incidence of job change $\Delta J_{i,r,t}$ of individual *i* in region *r* at time *t* as a function of *k* individual and *m* regional characteristics X_k and Z_m, as well as of the share of highly qualified workers $HC_{r,t}$ in region *r* at time *t*. In addition, we control for region and time fixed effects. Our main parameter of interest is τ, which indicates whether regional human capital endowments influence the probability of intra-regional job changes. We first estimate equation (2) for all moves in order to see whether human capital rich regions display a systematically different incidence of job change. We then estimate it separately by the number of prior moves to examine whether the importance of aggregate education decreases in the course of a worker's career. Finally, we investigate whether workers in skilled regions have changed jobs less often when exiting the labor market than workers in unskilled regions.

Throughout our analysis we employ the regional share of highly qualified workers as our preferred measure of regional human capital. This is due to the following two considerations. First, we follow Krueger/Lindahl (1999) in their argument that productivity effects from aggregate human capital are more likely to be rooted in the regional share of highly qualified workers, rather than in the overall average level of

education. Second, for reasons outlined below we restrict our sample to highly qualified workers. Since Kremer (1997) shows that individuals sort into networks which are homogenous with respect to social status, education, and abilities, we expect the presence of other highly qualified workers to be more relevant for career opportunities of highly qualified workers than average levels of education in general.

We exclusively focus on highly qualified workers throughout the analysis, i.e. we estimate the importance of matching externalities arising from regional human capital endowments for highly qualified workers only. Since Ciccone/Peri (2006) it is well known that imperfect substitutability between highly qualified and non-highly qualified workers constitutes a serious threat to the proper identification of human capital externalities. Due to supply and demand effects, an increase in the regional share of highly qualified workers depresses wages of highly qualified workers while increasing those of non-highly qualified workers. With an increasing supply of highly qualified workers we are thus prone to overestimate human capital externalities when not differentiating their effects by qualification. Since the primary objective in this paper is to provide first evidence on whether matching externalities exist as a microeconomic source of human capital externalities, we have decided to focus on highly qualified workers alone, well aware that doing so we are likely to underestimate the size of matching externalities from aggregate education.

We define labor market regions along the lines of the 75 '*Raumordnungsregionen*' defined by the Federal Office for Building and Regional Planning, which are equal to NUTSII regions (BfLR 1996). While these regions are not explicitly defined so as to reflect workers' commuting behavior they do, by principle of construction, always cover a core city and its surrounding periphery (see Kosfeld/Eckey/Tuerck 2006).

We restrict our analysis to workers who move jobs without moving regions. Focusing on intra-region job movers allows us to identify matching effects from regional human capital more clearly by avoiding bias from several confounding factors. The biggest threat to a proper identification of human capital externalities stems from the fact that regional human capital exhibits amenity and productivity effects alike (Roback 1982). Thus, while regional human capital increases workers' productivity, it also constitutes an amenity inasmuch as workers might be willing to accept wage reductions in exchange for living and working in a more educated environment. Reducing our sample to workers changing jobs within regions implies that wage reducing amenity effects do not affect wage growth on the occasion of job change since pre-move wages are already amenity adjusted.

Secondly, workers moving regions tend to be highly self-selected with respect to unobservable but productivity relevant characteristics like motivation or ambition. Not controlling for these characteristics would lead to an overestimation of effects from human capital externalities. Routinely, this problem is addressed by including worker fixed effects. While we intended to do so, the use of worker fixed effects was made impossible by the small number of job moves in our data. Due to the resulting high collinearity between the fixed effects and the move dummy, our estimators on move effects and on the interactions with aggregate human capital, which are central to our analysis, did not converge. In the absence of workers fixed effects, reducing our sample to workers changing jobs within regions can be regarded as a second-best option to reduce unobserved heterogeneity between workers.[7]

Restricting the sample to within-region movers allows us to explicitly investigate the importance of regional aggregate education for the efficiency of job matches within regional labor markets. However, since workers self-select into groups of movers and career networks are likely to be of a different importance for such groups, our results are only to a limited extent transferable to workers changing regions. Notwithstanding the problems of identification involved, we have therefore also estimated all our regressions for the full sample in order to see whether our results hold for all types of workers, i.e. also for those who change jobs between regions.

II.3. Human Capital Externalities and Matching: Data and Descriptives

Our empirical investigation is based on the IABS data set provided by the Institute for Labor and Employment Research in Nuremberg. The IABS is a two percent sample of all workers holding a job subject to social security contribution and contains longitudinal information on worker's employment histories, as well as on further individual characteristics (see Drews 2007 for a comprehensive description of the data). From this spell data we construct a panel data set encompassing all observations made on the 30th of June each year. This annualized panel data set contains more than 18 million observations for Western Germany between 1975 and 2004. The definition of worker status along the lines of social security contributions excludes self-employed workers as well as public servants.

One of the merits of the data set lies in its panel structure, which allows for tracking workers over time. Another merit is that the data are very reliable since they provide

[7] A minor problem we eliminate when restricting our sample to workers changing jobs within regions is that when changing regions workers are sometimes compensated for moving efforts by their future employer. These one-time payments are inseparably incorporated in our data on wages and might introduce upward bias into our estimations on the importance of matching effects.

the source for calculating social benefits entitlements, and employers are therefore obliged to submit them to the best of their knowledge. The flipside of data being generated from the employment register is that wages are top coded at the threshold of maximum social security payments.[5] We therefore have imputed wages above this threshold through predictions from a full set of individual characteristics (see Gartner 2005). Throughout the paper wages are defined as gross daily wages, which we have inflation adjusted to the 2004 Euro level. The education variable is a six-stage indicator containing information on a worker's highest degree of formal education. We have corrected for inconsistent coding of the education variable using an improved variable provided by Fitzenberger/Osikominu/Voelter (2006) and Drews (2006). Part-time employees, apprentices and trainees are excluded from the data, which leaves 12 million observations on about one million full time employees in Western Germany between 1975 and 2004. For reasons outlined above we further restrict our data to contain only highly qualified workers, defined as workers holding a degree from a university or a technical college. This restriction reduces the number of observations to 873,109. In order to investigate the importance of matching externalities from aggregate human capital we construct two subsamples.

The first subsample contains a balanced panel of workers, encompassing all highly qualified employees with a full set of observations between 1999 and 2004, i.e. workers with a total of six observations in this period. As argued above, we require these workers to stay within one region, i.e. to neither move employers nor houses between regions. We therefore exclude all workers moving jobs or regions, except those changing jobs within regions in 2000. This leaves us with 110,454 observations on 18,409 workers, out of which 1,143, i.e. 6.21 percent, move firms in 2000 without moving regions. We define a dummy variable which equals 1 (0) if a worker belongs to the group of movers (stayers). Earmarking the group of movers over the whole period of investigation, rather than just for the year 2000, we control for systematic and persistent unobservable differences between movers and stayers. Focusing on job moves occurring in 2000 eliminates bias from changing macroeconomic environments, or systematic changes of motives for job moves over time, e.g. due to business cycles.

While providing insight into the average size of matching effects from aggregate human capital, the drawback of using a balanced panel containing just one job move is that it does not allow for examining whether such matching effects change with the number of prior job moves. With our theoretical considerations in mind, we expect the effect from aggregate human capital on wage gains of job movers, as well as on

[5] The ten percent of workers earning wages above this threshold, which increases annually approximately in line with overall wage growth, are free to choose to either pay the maximum amount of social security payments, or to leave the public system and insure privately.

the propensity to change jobs, to decrease with the number of prior moves since workers in skilled regions are likely to have found an efficient job match earlier in life.

In order to address our second hypothesis and to corroborate our results obtained from the first sample we construct a second sample, which allows us to track workers from their career start over their employment life cycle. We construct this sample so as to contain only workers who show up for the first time in the data after 1975 (in order to avoid left-censoring), are below the age of thirty when observed for the first time, and who have a full set of observations until they either leave the labor market or until the sample ends in 2004.[8] We again make sure that these persons stay within one region throughout their working life. This leaves us with a sample of 155,680 observations on 23,187 workers, i.e. we observe workers on average for a period of 6.7 consecutive years. Since workers can change jobs several times, we observe 10,522 job changes made by 6,814 persons. Thus, workers change jobs on average .83 times during the period of observation. Conditional on changing jobs at all, the average number of job changes is 1.74. Since the number of observations naturally decreases for larger numbers of job moves, we merge all moves above the third within one category, which then contains 450 observations on a worker's fourth move or beyond.

Maps I and II provide evidence of the close correlation between the regional shares of highly qualified workers and average regional wages earned by highly qualified workers across the 75 regions in Western Germany. High average wages and human capital intensities follow the well-known 'hot banana pattern', i.e. they follow an imaginary line starting in the North-West in the Rhineland, crossing the Rhine-Main area and the automobile cluster around Stuttgart, and continuing down to the South-East, i.e. to Bavaria. With respect to the importance of human capital externalities as a determinant of wages across the regions in Western Germany, employing the regional number of students and the number of schools as instrumental variables for the share of highly qualified workers in a region, Heuermann (2008) shows that while sorting effects of workers of different education and ability play an important role for higher wages in human capital intensive regions, external effects from human capital raise wages of highly qualified workers by 1.8 percent with each additional percent in the share of highly qualified workers. Thus, a one standard deviation in the regional share of highly qualified workers is associated with an increase in wages of about eight percent for highly qualified workers. In the following analysis we investigate to which extent wage effects from human capital externalities are attributable to improved matching opportunities arising from a higher density of human capital.

[8] Quits from the sample can occur if workers change into the public service, become self-employed, become unemployed for more than a year, or leave the labor force altogether.

III. Matching as a Microeconomic Source of Human Capital Externalities

III.1. Between-Job Wage Adjustment: Evidence from a Balanced Panel

We start by examining wage developments within our balanced sample of workers. Graph I contains the evolution of average wages for the group of movers. With the exception of 2004, average wages increase over the whole period of observation at an average annual rate of 1.5 percent. Of particular interest is the wage jump occurring at the time of job change, i.e. between 1999 and 2000, where average wages rise by about four percent from below 118 to above 122 Euros. In what follows we examine the extent to which this wage growth is driven by gains from matching externalities.

Table I contains the results from estimating equation (1). All coefficients on individual characteristics are in line with the broad empirical literature, i.e. wages grow at a decreasing marginal rate with age, tenure, and experience. Furthermore, university graduates receive a wage premium of about eight percent compared to graduates from technical colleges, while women's wages are 37 percent below those of their male colleagues. These coefficients are constant across all wage regression in both samples and are not commented on further.

All columns consistently show that workers who move jobs in 2000 incur substantial wage gains from human capital externalities. While the overall effect of the regional share of human capital on wages of all workers ('*Regional Share HQ*') is insignificant throughout all regressions, the significantly positive coefficient on the interaction term in Column I indicates that with a one percent increase in the regional share of human capital, wages of moving workers rise by .35 percent. Thus, an increase in the share of highly qualified workers by one standard deviation, i.e. by about 5.5 percent, is associated with wage gains of about two percent incurred by the group of movers.

In columns II to V in Table I we have differentiated the impact of regional human capital on wages of moving workers by year in order to see whether wage gains occur in the year of moving ('*Move Dummy*Regional Share HQ, 2000*'), which in line with our first hypothesis we would take as evidence that human capital externalities unfold through improved matching opportunities in skilled regions. The crucial insight from all four regressions is that on the incidence of moving jobs, i.e. in the year 2000, workers experience wage gains of between .27 and .58 percent with each additional percent of regional human capital. Our most comprehensive specification in column V confirms that matching externalities arising from aggregate human

capital increase wages at the time of moving by about .6 percent with every additional percent in the regional share of highly qualified workers. Thus, a one standard deviation of the share of highly qualified workers raises wages of job movers by about 3.2 percent. Insignificant coefficients on human capital externalities in all other years emphasize that benefits from regional human capital accrue to workers only in the event of a job change, i.e. through matching effects. Graph II summarizes the coefficients and confidence intervals obtained in this regression.

Two further insights emerge from columns III to V. We first differentiate the impact of regional human capital on all workers ('*Regional Share HQ*') by year. Coefficients, which are not shown here, are insignificant for each year. In addition, our results on the impact of aggregate human capital on the wages of job movers remain unchanged. Both results confirm that human capital externalities unfold wage effects predominantly through more productive job matches of workers changing jobs. Second, we split up the move dummy ('*Move Dummy*') by year in order to control for changes in systematic differences between movers and stayers. Doing so, we find that human capital effects after job moves lose significance, while the size of matching externalities doubles. These results confirm the findings by Freedman (2008) that workers are self-selected inasmuch as they accept lower wages when changing jobs but incur larger wage gains after job moves.

Two explanations come to mind for the significantly negative move dummy. Freedman (2008) argues that workers are willing to accept wage losses when changing jobs since they expect to benefit from steeper wage growth through improved career opportunities thereafter. Alternatively, Lehmer/Moeller (2008) show that workers are self-selected with respect to pre-move wages, i.e. low-paid workers are more likely to change jobs. We have split up the move dummy by year in column IV so as to shed light on the issue. Results, which are not shown here, indicate that both arguments apply since wages of movers are significantly lower in the first two years of observation and increase faster, though not significantly, in the four years thereafter.

Our result that external human capital effects for workers other than job movers are insignificant stands in contrast to prior findings in the empirical literature. Such insignificance is likely to be driven by the short time horizon covered by our sample, rather than by the absence of genuine human capital externalities for job stayers. In fact, effects from aggregate human capital can arise only from intra-regional shifts in aggregate education, since level effects are captured altogether by our region fixed effects. As the sample covers a period of six years only, intra-regional variances in the share of highly qualified workers are probably too small to yield significant effects.

III.2. Between-Job Wage Adjustment: Evidence from an Unbalanced Panel

In order to corroborate these results and to examine whether matching externalities from aggregate human capital decline with the number of prior job moves we employ our second, unbalanced panel of workers. Specifically, rather than comparing the development of wages of a group of movers to that of non-movers, we now compare wage increases on the incident of a job move to wage developments of workers staying in their job. Technically, our move dummy therefore does not identify a worker as a mover any more, but indicates the incidence of a job move.

Columns I to III in Table II confirm our results obtained from the balanced sample of workers. Consistently, we find regional human capital externalities to raise wages at the time of a job change by between 2. and .3 percent with each additional percent in the regional share of human capital. Thus, increasing the share of highly qualified workers by one standard deviation is associated with between-job wage gains by about 1.7 percent. It is worth noting that in line with results from the first sample, without human capital externalities movers would incur wage losses of about .02 to .05 percent in the year after moving, again indicating the self-selection of movers.

In column II we run the same regression for the full sample of workers. Interestingly, if we include workers changing jobs across regions, matching effects from aggregate human capital fully disappear. As discussed above, this result is probably rooted in three mechanisms. First, since aggregate education is likely to unfold amenity effects, workers changing regions might be willing to accept lower wages in order to be close to higher aggregate levels of human capital. Such wage depressing amenity effects might eat up productivity effects from human capital and thereby render the coefficient insignificant. Second, workers changing regions are likely to be self-selected with respect to motivation and ambition. These effects are reflected in the move dummy, which is now significantly positive. If more motivated workers move to regions with larger human capital endowments, our specification does not allow for disentangling effects from human capital externalities from those arising from higher motivation. Thus, a potentially close correlation between the decision to move and regional human capital endowments might drive the highly significant move dummy, while yielding an insignificant interaction term. Finally, these results might be indicative for the localized nature of career networks. As argued above, such networks work best if workers change jobs on a regional scale. While certainly not definite on the issue, the fact that regional human capital does not lead to productivity effects for workers changing regions indirectly supports the notion that career networks work best if workers change jobs within regions.

In column III we juxtapose matching externalities arising from aggregate human capital to those arising from urban density. In line with the notion that information on potential job matches and their quality is more important for efficient labor market matches than the mere availability of jobs and workers, we find matching effects to be rooted in the density of human capital, rather than in the extent of agglomeration. In fact, while the size of the matching effect from aggregate human capital remains largely unchanged, the interaction between the move dummy and urban density is insignificant.

Results obtained from the unbalanced sample provide insight into the relative importance of matching externalities as a microeconomic source of human capital externalities. As mentioned, human capital externalities raise wages of all workers by about .5 percent with each additional percent of highly qualified workers, independent of whether workers move jobs or not. However, such productivity enhancing effects are prone to be underestimated since with the existence of amenity effects from human capital workers are willing to incur wage losses for being close to other skilled workers (Roback 1982). According to Shapiro (2006), productivity effects account for about two thirds of the social returns to human capital and amenity effects for the remaining third. Thus, productivity effects from aggregate human capital are likely to range somewhere around .8 percent for all workers. Job movers incur an additional .3 percent at the time of changing firms. Since workers in our sample change jobs only within regions, amenity effects are already included in their pre-move wages and continue to be so in post-move wages. Wage gains on the incidence of job moves are therefore not influenced by amenity effects and simply reflect increases in productivity. Given this reasoning, the productivity of movers rises by 1.1 percent with each additional percent of highly qualified workers in the workforce. With .3 percent points of this effect arising at the time of moving, matching effects from aggregate human capital account for about thirty percent of overall productivity enhancing returns to human capital.

The finding that wage effects from aggregate education accrue to a substantial extent to moving workers is in line with a dynamic interpretation of localized economies of scale gaining prominence. In fact, it is increasingly acknowledged that benefits from economic density do not automatically accrue to all workers alike, but are mainly incurred by workers who change jobs in urban and thereby reap gains from matching opportunities. In this vein, Yankow (2006: 160) argues that "coordination efficiencies in dense urban settings have a prominent role to play in any comprehensive explanation of the urban wage premium". Analogously, human capital externalities arise to a large extent through improved labor market coordination in skilled regions.

We finally differentiate the occurrence of matching effects by the number of prior job moves. Results from this exercise, which are documented in column IV, suggest that benefits from improved matching opportunities increase from the first to the second move, while becoming insignificant thereafter. The finding of an inverted U-shape of benefits from matching externalities to arise over the life cycle supports the idea that increasing the share of highly qualified workers enables workers to learn about job and career opportunities early in their working life and to capitalize on this knowledge through improved job matching during the first two job changes. However, two caveats apply. On the one hand, the number of workers changing jobs more than twice becomes very small with 841 workers being observed changing jobs for the third time, and 450 at the point of a fourth job change, compared to 6,814 first, and 2,417 second job changes. The decreasing incidence of job changes of higher ranks might inflate standard errors, which in turn decreases the reliability of estimates with an increasing number of job changes. Secondly, motives of job change might become more diverse over time. Thus, one might argue that career perspectives can be expected to play a dominant role as a motive for job change first and foremost in earlier stages of a workers life. Consequently, career networks might lose importance not because they transmit less usable information, but because workers preferences for making a career change over time. In this respect it is unfortunate that our dataset does not allow us to control for job changes occurring voluntarily or involuntarily, a distinction which can be expected to matter for wage developments over time. Thus, while our results need validation from other data sets which allow for the inclusion of motives of job change, our findings from the wage regressions strongly support the notion that productivity enhancing human capital externalities arise through improved matching opportunities in skilled regions.

III.3. The Probability of Job Moves

Table III contains results from Probit regressions on individual and aggregate determinants of job changes. We use both samples in order to corroborate our results. We restrict the first sample to the year 2000, since by means of construction job changes only occur in that year. Thus, we investigate the determinants of job moves for a cross-section of 18,409 workers, out of which 1,143 change jobs. Restricting the dataset like this impedes the use of time or region fixed effects. The second sample encompasses all 155,272 observations. The dependent variable throughout all regressions is the incident of job change, irrespective of the number of prior moves.

Due to differences in the samples (with the first sample covering all workers in 2000 and the second sample consisting of observations on young workers between 1976 and 2004) the coefficients on individual variables vary slightly. However, all coefficients

show the same plausible signs in all regressions. Age and experience follow an inverted U-shape pattern, indicating that the probability of job change first increases with age and labor market experience, and declines thereafter. Thus, in line with Battu/McMaster/White (2002), we find that job change is primarily an issue of earlier stages of a worker's career. In contrast, the probability of job change decreases with tenure. This is consistent with theoretical arguments by Jovanovic (1979) and empirical findings by Mincer/Jovanovic (1981) and Farber (1999), who show that the disclosure of information on the quality of a job match is initially high and declines over time, leading to a gradually decreasing probability of job change. Finally, women change jobs more often, while we find basically no difference in the job change behavior between university graduates and graduates from a technical college.

The regional share of highly qualified workers exerts a significantly positive influence on the probability of job change, indicating that workers change jobs more often in skilled regions. Results are very similar across the two samples. In fact, an increase of the share of highly qualified workers by one standard deviation increases the annual probability of job change by between .1 and .3 percent in both samples. Graph III contains a simulation of the probability of job change as a function of regional human capital endowments based on the linear specification contained in column IV. The probability of job change increases monotonically with the regional share of highly qualified workers at a growing marginal rate. Thus, raising the regional share of highly qualified workers by one standard deviation to its mean in 2004, i.e. from three to eight percent, is associated with an increase in job change probability of about .1 percent, while a rise by one standard deviation from eight to thirteen percent increases the probability by more than .3 percent. Workers in regions with a share of regional human capital exceeding seventeen percent are about one percent more likely to change jobs in a given year due to human capital externalities compared to workers in cities with human capital shares below five percent.

The finding that job change probabilities increase more than proportionally with human capital intensity suggests that career networks are predominantly an issue of highly qualified cities, whereas for intermediate levels of human capital intensity effects from improved matching opportunities are not overwhelmingly large. Typically, regions with high shares of highly qualified workers are characterized by a strong clustering of industries. These regions encompass Frankfurt (banking), Ludwigshafen (chemical industry), Stuttgart (automobile industry), and Munich (computer engineering). It is therefore very likely that matching efficiencies do not only depend on the level of regional human capital, but also on the extent to which regional industrial compositions allow workers to capitalize on their industry-specific

human capital. Accordingly, Fallick/Fleischman/Rebitzer (2006) provide evidence that high job-hopping rates in Silicon Valley identified by Saxenian (1994) are entirely driven by job movers within the computer industry, while job changing rates within other industries are not significantly higher than elsewhere. We provide evidence on the importance of within-industry moves for the occurrence of matching externalities below. Before doing so, two further comments are in order, one relating to our results on agglomeration effects, and one on the changing importance of human capital networks for job matching in the course of a worker's career.

Turning to agglomeration, in contrast to Finney/Kohlhase (2007), we find only limited evidence for a positive impact of regional agglomeration on the probability of job change. In contrast, while aggregate education is a robust predictor of job change across both samples, urban density unfolds significant effects only in our first sample. Thus, our findings suggest that the local density of human capital is at least as important as regional labor market size for the propensity to change jobs. We do admit, however, that the impact of agglomeration on job change probabilities might be more complex than we have modeled it here. The results by Bleakley/Lin (2007) point to pronounced nonlinearities in the importance of agglomeration for job changes. Acknowledging that the size of labor market might matter in different and potentially more complex ways than investigated here we leave this issue for further investigation within the literature on agglomeration externalities.

With respect to the changing importance of human capital networks in the course of workers' careers, in Table IV we estimate the probability of a move conditional on the number of prior moves. Technically, our move dummy in each regression equals one if a move of a specific rank is observed, e.g. in column I (II) the dependent variable equals one if a worker makes his first (second) job move. In order to avoid logical inconsistencies, we exclude moves of higher ranks from each regression. Theoretically, the number of observations should therefore rise with the number of prior moves, which is why column I contains more observations than column II. This number decrease in column III and IV since in some years in some regions no job change is observed, which necessitates that for reasons of identification all observations within these entities are dropped.

As our core result we find regional human capital to be statistically significant only for a worker's first move, indicating that human capital networks are relevant first and foremost in early stages of a worker's career. Analogously, Wheeler (2008) finds that agglomeration facilitates the search for an efficient job match early in life. While following Wheeler in his argument that external labor market structures are of prime

importance especially early in a worker's career, we do not find evidence for an important role of agglomeration in and by itself in our sample of highly qualified workers. Instead, highly qualified workers seem to profit from the density of human capital rather than from market size alone.

Finally, we employ Tobit regessions in order to shed light on the impact of regional human capital on the total number of job moves made by a worker during the period of observation. Doing so allows us to indirectly assess whether career networks in skilled regions enable workers to find an efficient job match earlier than their colleagues in regions shaped by lower human capital endowments. As our dependent variable we use the total number of job moves made by a worker, which is bounded between 0 and 4, and estimate it as a function of a full set of individual and aggregate characteristics. The results are contained in column V in Table IV. Using a linear specification we find regional human capital to significantly reduce the overall number of job moves. More specifically, workers in regions characterized by a regional share of highly qualified workers of one standard deviation below the mean have changed jobs on average .2 times more than their colleagues in regions with an average share. With respect to agglomeration, we find that increasing the size of a region by twenty-five thousand workers increases the average number of job changes by one. A word of caution is in order, though. For reasons outlined above our sample is constructed so as to track workers in their careers as long as they stay within one region. It could theoretically be that our results are driven by an increased probability of workers in human capital intensive regions to change regions more often and therefore to drop out of our sample earlier. Although we do not find evidence for different lengths of observations in our data, our results on the impact of regional human capital on the total number of job changes need further validation. We leave this as an avenue for further research, drawing the preliminary conclusion that while matching externalities in skilled regions raise the probability of changing jobs early, they reduce the overall number of job changes needed for workers to find an efficient labor market match.

IV. Human Capital Externalities and the Transfer of Industry-Specific Human Capital

Results obtained so far are supportive of the idea that human capital networks improve matching efficiency in the labor market by providing ex ante information on the quality of a job match between workers and employers. Among other things, the quality of such a match depends on the extent to which a worker can transfer his

knowledge and experience obtained in past positions into a new environment and thereby continues to use it productively. With respect to industry-specific knowledge, successful transfers are most likely if workers change between firms within one industry. Career networks might therefore play an important role in enabling workers to continue their career within one industry and allow them to capitalize on their experience obtained in past jobs. Accordingly, existing studies in the literature on agglomeration have confirmed that benefits from agglomeration are partly rooted in the fact that cities are home to larger industries, which in turn facilitates the transfer of industry-specific knowledge between jobs (Freedman 2008, Wheeler 2008). We follow this line of enquiry by examining whether career networks enable workers to reap benefits by facilitating job changes within industries. We therefore first investigate the existence of industry-specific human capital by analyzing whether benefits are different for job matches between industries and within industries. We then examine whether workers are more likely to stay within an industry in human capital intensive regions.

Column V in Table II contains our results from an estimation of wage gains from matching externalities differentiated by the type of job move. The coefficients on the interaction terms emphasize the importance of industry-specific human capital by indicating that aggregate human capital yields matching benefits only to workers changing jobs within an industry. More specifically, when disaggregating industry-wage regressions by number of move we find the same pattern of benefits as in our general analysis, i.e. matching externalities arise predominantly with the first two intra-industry job changes, while becoming insignificant thereafter (results not shown here). With respect to the importance of career networks, this finding suggests that such networks predominantly carry information about job opportunities within an industry and thereby increase the chances of workers to capitalize on their industry-specific human capital. In contrast, when changing jobs to other industries, between-job wage growth does not depend on regional human capital. However, differences in the motives of job change may induce a hidden source of heterogeneity between intra-industry and between-industry changers. While for reasons outlined above we cannot directly test for such heterogeneity, we are confident that the bulk of self-selection effects are captured by the move dummy rather than by the interaction term. This interpretation hinges on the assumption that unobserved heterogeneity between workers does not systematically change with the density of human capital.

If only workers who change jobs within their own industry profit from increased matching opportunities arising from the density of highly qualified workers, we should find that workers in human capital intensive areas predominantly change jobs within their own industry in order to reap the gains from such matching externalities.

We therefore reduce our two samples to their respective subsample of job movers and employ Probit regressions in order to estimate the probability of industry change as a function of regional human capital, conditional on a worker changing jobs.

Table V contains the results of this estimation. Column I shows that for the first sample of job movers the probability of industry change declines with the regional share of highly qualified workers. This result is, however, not robust to the inclusion of the agglomeration variables as further controls. Thus, while still negative, the coefficient on regional human capital density becomes insignificant. Since this regression is based on a cross section of observations only, a proper identification is impeded by strong multicollinearities between human capital density and agglomeration due to the relatively small number of observations. A larger number of observations in the second dataset solves this problem.

Column II in Table V contains our results from using the second sample of job movers. The regional share of highly qualified workers again unfolds a negative impact on the propensity of job changers to change industries. This result is not only robust to the inclusion of increasing returns from agglomeration, but even increases in size. Based on the results in column III, Graph IV contains a simulation of the probability of an industry change associated with changes in the regional density of human capital. It shows that the negative effect is, indeed, large. With a share of regional human capital below five percent, the overall probability of a worker changing industries when changing jobs ranges around sixty percent. In regions characterized by a share of highly qualified workers of above fifteen percent this probability reduces to well below forty percent. In general, increasing the regional share of human capital by one standard deviation decreases the probability of industry change by about ten percent.

In column IV we split up the propensity of changing industry by the number of prior job moves. This line of inquiry is inspired by Wheeler (2008), who finds that industry changes occur less frequently in later phases of a worker's life cycle. We find no such evidence. In fact, the negative impact of human capital networks on the probability of industry changes remains remarkably constant over time. This indicates that workers use information networks over their life cycle in order to stay within their industries. In contrast to Bleakley/Lin (2007), who show that workers of all educational backgrounds change occupation and industry less frequently in agglomerated areas, we find that highly qualified workers mainly benefit from the density of human capital, which allows them to change jobs within industries. One slight contradiction seems to emerge, however. While from the third move onwards

gains from changing jobs within industries do not capitalize in wages anymore, workers still continue to change jobs within industries in later stages of their careers. Possibly, the number of cases gets too small to allow for a proper identification of wage gains with a higher number of job changes. Alternatively, workers stay in their industries due to a preference for doing a job they are familiar with. Thus, while we cannot say exactly what happens after the second move, the general picture emerging from the data supports the idea that information networks embedded in the density of regional human capital enable workers to gather information on superior job matches which allow them to capitalize on their industry-specific human capital. Thus, it is through the opportunity of changing jobs within industries that regional human capital enables young workers to climb up the income ladder more quickly especially in early stages of their career.

V. Conclusion

This paper set out with the intent to take Gilles Duranton's advice serious and to try to shed light on the microeconomic foundations of human capital externalities. Inspired by a voluminous literature on the importance of social networks for career perspectives, we investigated whether productivity enhancing effects of regional human capital endowments come about through an improved quality of job matches in human capital rich regions. Employing two samples of highly qualified workers from Germany we examined the extent to which regional differences in between-job wage growth and in job moving behavior are attributable to differences in regional educational endowments as measured by the share of highly qualified workers. Our findings strongly support the notion that regional human capital externalities are rooted in improved job matching opportunities arising from a more efficient flow of information on career and job opportunities. Three core findings emerge.

First, we find an increase of the share of highly qualified workers by one standard deviation to be associated with wage gains of job movers between 1.5 to 3.2 percent. This finding support the idea that highly qualified workers profit from having access to a dense network of other highly qualified workers, which we interpret as being indicative of a more widespread diffusion of labor market information within career networks leading to more efficient job matches.

Second, an increase in the share of highly qualified workers by one standard deviation raises the annual probability of a job change by up to .4 percent. Differentiating this impact by the number of prior job moves we find it to be especially pronounced in

early stages of a workers' career. Combined with the insight that workers change jobs less often in skilled regions, this result supports the notion that career networks allow highly qualified workers to change jobs early in their career up to a point where they find a job match of sufficient quality within which they stay thereafter.

Third, the occurrence of matching externalities from aggregate human capital is driven by the fact that career networks allow workers to change jobs within industries, allowing them to capitalize on their industry-specific human capital. This result is rooted in our finding that conditional on changing jobs, between-job wage gains accrue only to those workers who change jobs within industries. Consistent with this finding, workers in human capital intensive areas are more likely to change jobs within, rather than between industries.

While providing first evidence on the importance of improved job matching as a microeconomic foundation of human capital externalities, our study leaves a number of questions for further research. First, so far we only have provided evidence that highly qualified workers profit from dense networks consisting of their likes. In order for a coherent picture of human capital externalities to emerge, the analysis should be extended to examine the importance of different measures of aggregate human capital for groups of different educational backgrounds. In effect, this amounts to testing whether Krueger/Lindahl (1999) are right in assuming that the two types of aggregate human capital unfold dissimilar effects for different parts of the population. Up to now, uncertainty on the size and the underlying mechanisms through which different types of human capital externalities for different educational groups prevails. In fact, while Moretti (2004b) argues that human capital externalities are more pronounced for workers of lower skills groups in the US, Heuermann (2008) finds the reverse using data on Germany. For a deeper understanding of the mechanisms underlying such diverging results, future research on human capital externalities is encouraged to go beyond a mere quantification of external effects from human capital and to further the identification of the microeconomic sources of human capital externalities. In this respect we regard the taxonomy by Duranton/Puga (2004) of sharing, matching, and learning, as well as the empirical study by Charlot/Duranton (2004) on the importance of workplace communication for human capital externalities, as ideal starting points for future investigations.

A deeper understanding of the detailed mechanisms through which human capital externalities arise for different subgroups is of prime importance for the design of labor market, regional, and educational policies. While with the existence of externalities the need for public action is self-evident, the design and implementation

of efficient policy measures is blurred by the lack of knowledge about, first, the relative importance of the microeconomic mechanisms through which human capital externalities arise and, secondly, about which type of aggregate education is most important for different educational groups so as to maximize their benefits from human capital externalities. In the words of Duranton (2006: 37), "after 10 years of work on human capital externalities in cities, there is a strong suspicion that 'something is going on', a weaker suspicion that such externalities might be quite large, and a hunch that direct interactions might not be everything". Given the considerable cost of educational systems, more insights into how external effects from education come about and how social returns from aggregate human capital are distributed among different groups is clearly needed so as to design appropriate and well informed policy measures which are able to maximize society's gains from education and to thereby enhance productivity and growth.

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Appendix

Table I – Do Workers Benefit from Regional Human Capital when Changing Jobs?

	Dependent Variable: Ln(Individual Daily Gross Wage)				
	(I)	(II)	(III)	(IV)	(V)
Age	.006 (.001)***	.006 (.001)***	.006 (.001)***	.006 (.001)***	.006 (.001)***
Age^2	-.0001 (.00001)***	-.0001 (.00001)***	-.0001 (.00001)***	-.0001 (.00001)***	-.0001 (.00001)***
Experience	.012 (.0009)***	.012 (.0009)***	.012 (.0009)***	.012 (.0009)***	.012 (.0009)***
Experience^2	-.00003 (.00003)	-.00002 (.00003)	-.00002 (.00003)	-.00002 (.00003)	-.00002 (.00003)
Tenure	.004 (.0007)***	.004 (.0007)***	.004 (.0007)***	.004 (.0007)***	.004 (.0007)***
Tenure^2	-.00007 (.00002)***	-.00008 (.00002)***	-.00008 (.00002)***	-.00008 (.00002)***	-.00008 (.00002)***
Sex	-.369 (.002)***	-.369 (.002)***	-.369 (.002)***	-.369 (.002)***	-.369 (.002)***
University Degree	.083 (.002)***	.083 (.002)***	.083 (.002)***	.083 (.002)***	.083 (.002)***
Regional No of Workers	-.003 (.004)	-.004 (.004)	-.003 (.005)	-.003 (.004)	-.002 (.005)
Regional Share HQ	-.346 (.360)	-.444 (.361)	Split up by Year, results not shown	-.372 (.363)	Split up by Year, results not shown
Move Dummy	-.056 (.015)***	-.047 (.015)***	-.047 (.015)***	Split up by Year, results not shown	Split up by Year, results not shown
Move Dummy*Regional Share HQ	.345 (.107)***	Split up by Year	Split up by Year	Split up by Year	Split up by Year
Move Dummy*Regional Share HQ, 1999	-	-.029 (.139)	-.038 (.140)	.381 (.279)	.341 (.285)
Move Dummy*Regional Share HQ, 2000	-	.268 (.136)**	.269 (.136)**	.560 (.268)**	.582 (.275)**
Move Dummy*Regional Share HQ, 2001	-	.329 (.131)***	.331 (.131)**	.067 (.258)	.066 (.264)
Move Dummy*Regional Share HQ, 2002	-	.397 (.126)***	.401 (.126)***	.207 (.249)	.232 (.255)
Move Dummy*Regional Share HQ, 2003	-	.385 (.123)***	.383 (.123)***	.351 (.250)	.346 (.255)
Move Dummy*Regional Share HQ, 2004	-	.320 (.123)***	.319 (.123)***	.150 (.254)	.144 (.259)
Year Dummies	Yes	Yes	Yes	Yes	Yes
Region Dummies	Yes	Yes	Yes	Yes	Yes
Sample	Sample I, All Workers Staying in a Region	Sample I, All Workers Staying in a Region	Sample I, All Workers Staying in a Region	Sample I, All Workers Staying in a Region	Sample I, All Workers Staying in a Region
Adj. R^2	.24	.24	.24	.24	.24
No. of Observations	110,454	110,454	110,454	110,454	110,454

Notes: Standard errors in parentheses; ***, **, and * indicate significance at the 1% level, the 5% level, and the 10% level respectively; coefficients for constants are not reported here; coefficients and standard errors for Regional Number of Workers are multiplied by 1,000; the education variable equals 0 for '*Degree from a Technical College*' and 1 for '*Degree from a University*'; the variable on a worker's sex equals 0 for '*Male*' and 1 for '*Female*'.

Table II – Do Workers Benefit from Regional Human Capital when Changing Jobs?

	Dependent Variable: Ln(Individual Daily Gross Wage)				
	(I)	(II)	(III)	(IV)	(V)
Regional Share HQ	.521 (.111)***	.433 (.083)***	.526 (.111)***	.516 (.111)***	.344 (.123)***
Regional No of Workers	-.003 (.001)**	-.003 (.001)**	-.003 (.001)**	-.003 (.001)**	-.002 (.001)
Move Dummy	-.019 (.009)**	.028 (.005)***	-.020 (.009)**	-	-
Move Dummy*Regional Share HQ	.272 (.078)***	.007 (.046)	.219 (.105)**	-	-
Move Dummy*Regional No of Workers	-	-	.0006 (.0007)	-	-
Move Dummy, 1st Move	-	-	-	-.006 (.011)	-
Move Dummy, 2nd Move	-	-	-	-.061 (.020)***	-
Move Dummy, 3rd Move	-	-	-	-.045 (.035)	-
Move Dummy 4th Move	-	-	-	-.154 (.049)***	-
1st Move Dummy*Regional Share HQ	-	-	-	.287 (.096)***	-
2nd Move Dummy*Regional Share HQ	-	-	-	.485 (.159)***	-
3rd Move Dummy*Regional Share HQ	-	-	-	.218 (.276)	-
4th Move Dummy*Regional Share HQ	-	-	-	.642 (.379)*	-
Move Dummy, Intra-Industry Move	-	-	-	-	-.053 (.014)***
Move Dummy, Inter-Industry Move	-	-	-	-	.009 (.013)
Intra-Industry-Move Dummy*Regional Share HQ	-	-	-	-	.520 (.125)***
Inter-Industry-Move Dummy*Regional Share HQ	-	-	-	-	.061 (.114)
Year Dummies	Yes	Yes	Yes	Yes	Yes
Region Dummies	Yes	Yes	Yes	Yes	Yes
Sample	Sample II, All Workers Staying in a Region	Sample II, All Workers	Sample II, All Workers Staying in a Region	Sample II, All Workers Staying in a Region	Sample II, All Workers Staying in a Region
Adj. R^2	.33	.32	.33	.33	.33
No. of Observations	155,680	268,383	155,680	155,680	155,680

Notes: Since coefficients on individual attributes are similar to those in Table I, they are not displayed here; standard errors in parentheses; ***, **, and * indicate significance at the 1% level, the 5% level, and the 10% level respectively; coefficients for constants are not reported here; coefficients and standard errors for Regional Number of Workers and interactions terms containing Regional Number of Workers are multiplied by 1,000.

Table III – Does Regional Human Capital Increase the Probability of Intra-Regional Job Moves?

	Dependent Variable: Incident of Job Change				
	(I)	(II)	(III)	(IV)	(V)
Age	.035 (.027)	.033 (.027)	.130 (.015)***	.129 (.015)***	.130 (.015)***
Age^2	-.0004 (.0003)	-.0004 (.0003)	-.0007 (.0002)***	-.0007 (.0002)***	-.0007 (.0002)***
Experience	.104 (.015)***	.105 (.015)***	.289 (.005)***	.290 (.005)***	.290 (.005)***
Experience^2	-.003 (.0005)***	-.003 (.005)***	-.012 (.0003)***	-.012 (.0003)***	-.012 (.0003)***
Tenure	-.897 (.022)***	-.899 (.022)***	-.975 (.008)***	-.975 (.008)***	-.975 (.008)***
Tenure^2	.031 (.0008)***	.031 (.0008)***	.034 (.0003)***	.034 (.0003)***	.034 (.0003)***
Sex	.018 (.048)	.018 (.048)	.147 (.015)***	.147 (.015)***	.147 (.015)***
University Degree	-.045 (.045)	-.045 (.045)	.029 (.016)*	.029 (.016)*	.029 (.016)*
Regional Share HQ	.953 (.874)	13.2 (3.87)***	1.75 (.726)**	2.33 (.835)***	5.76 (2.53)**
Regional Share HQ^2	-	-47.8 (15.0)***	-	-	-9.52 (6.80)
Regional No of Workers	.008 (.004)*	.062 (.020)***	-	-.014 (.009)	-.043 (.045)
Regional No of Workers^2	-	.000003 (.0000007)***	-	-	.0000008 (.000001)
Year Dummies	No	No	Yes	Yes	Yes
Region Dummies	No	No	Yes	Yes	Yes
Sample	Sample I, All Workers in 2000 Staying in a Region	Sample I, All Workers in 2000 Staying in a Region	Sample II, All Workers Staying in a Region	Sample II, All Workers Staying in a Region	Sample II, All Workers Staying in a Region
Adj. R^2	.49	.49	.46	.46	.46
No. of Observations	18,409	18,409	155,272	155,272	155,272

Notes: Standard errors in parentheses; ***, **, and * indicate significance at the 1% level, the 5% level, and the 10% level respectively; coefficients for constants are not reported here; coefficients and standard errors of Regional No of Workers, as well as of squares thereof, are multiplied by 1,000; the education variable equals 0 for '*Degree from a Technical College*' and 1 for '*Degree from a University*'; the variable on a worker's sex equals 0 for '*Male*' and 1 for '*Female*'.

Table IV – When Does Regional Human Capital Influence Job Change Decisions?

Dependent Variable:	Occurrence of Job Change, by Number of Change					Total Number of Job Changes
	(I)	(II)	(III)	(IV)		(V)
Regional Share HQ	2.45	1.39	1.45	2.03		-4.38
	(1.09)**	(1.32)	(2.26)	(3.33)		(2.10)**
Regional No of Workers	-.015	-.0001	.007	.014		.047
	(.012)	(.015)	(.027)	(.043)		(.021)**
Year Dummies	Yes	Yes	Yes	Yes		Yes
Region Dummies	Yes	Yes	Yes	Yes		Yes
Sample	Sample II, All Workers Staying in a Region	Sample II, All Workers Staying in a Region	Sample II, All Workers Staying in a Region	Sample II, All Workers Staying in a Region		One Observation per Worker, Workers Staying ina Region, Sample II
Number of Change	1st Change	2nd Change	3rd Change	4th Change		-
Number of Changers	6,814	2,417	841	450		-
Pseudo R^2	.59	.30	.33	.36		.073
No. of Observations	151,564	153,199	147,841	131,762		23,187

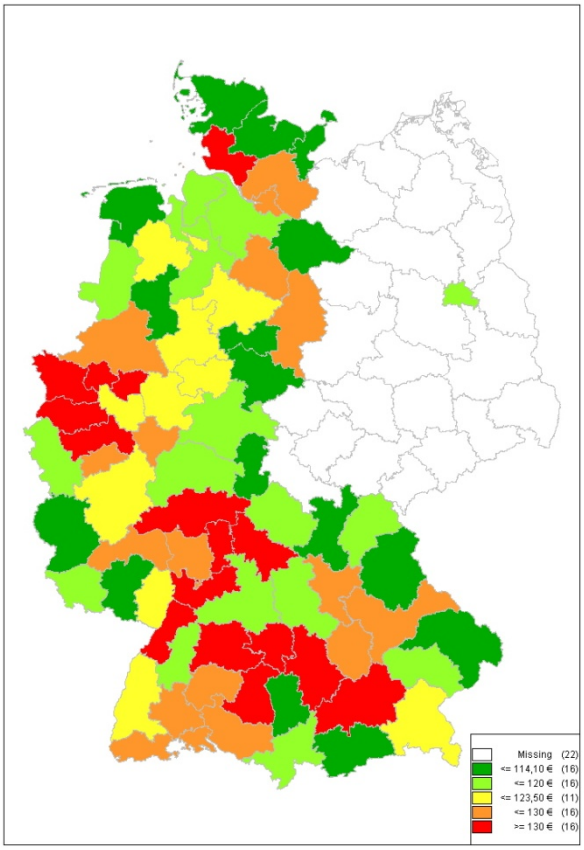
Notes: Results in columns I to IV are based on Probit regressions; Tobit regressions in Column V are bounded by 0 and 4; standard errors in parentheses; ***, **, and * indicate significance at the 1% level, the 5% level, and the 10% level respectively; coefficients for constants are not reported here; coefficients and standard errors for Regional No of Workers as well as for squares thereof are multiplied by 1,000; control variables not listed in the table are Sex, Age, Age (squared), experience, experience (squared), tenure, tenure(squared), and education for Columns I to IV, and Sex and Education for Column V.

Table V – Do Workers Change Industries More/Less Frequently in Human Capital Intensive Regions?

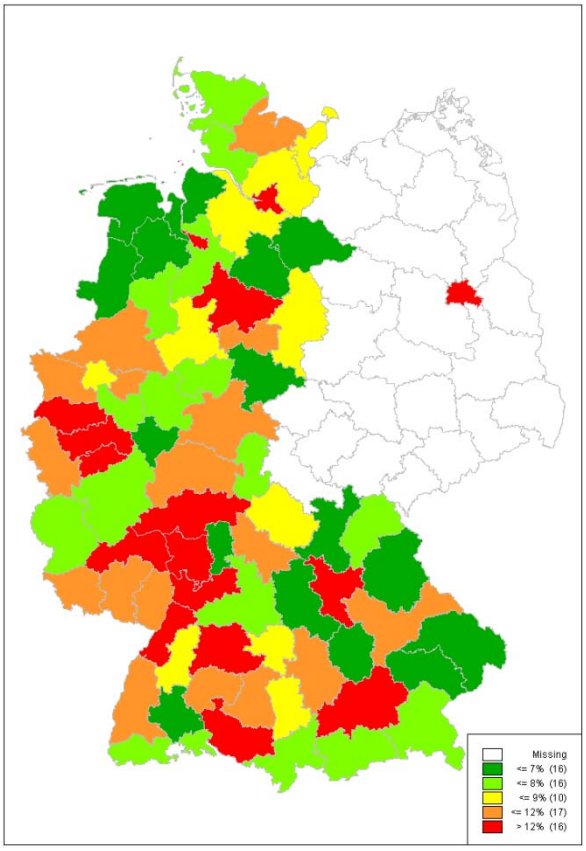
	Dependent Variable: Incident of Industry Change, Conditional on Job Change			
	(I)	(II)	(III)	(IV)
Age	-.006 (.051)	-.037 (.031)	-.011 (.028)	-.012 (.028)
Age^2	.00006 (.0006)	.0004 (.0005)	.00007 (.0004)	.00076 (.0004)
Experience	-.040 (.029)	.015 (.012)	.012 (.011)	.009 (.011)
Experience^2	.0004 (.001)	-.001 (.0006)**	-.001 (.0005)**	-.001 (.0005)*
Tenure	-.072 (.056)	-.035 (.022)	-.041 (.020)**	-.047 (.021)**
Tenure^2	.005 (.004)	-.002 (.001)	.003 (.001)**	.004 (.001)***
Sex	.145 (.088)*	-.028 (.031)	-.021 (.029)	-.026 (.029)
University Degree	.057 (.080)	-.036 (.031)	-.002 (.029)	-.003 (.029)
Regional Share HQ	-2.13 (.996)**	-4.02 (1.51)***	-4.11 (1.29)***	-
Regional No of Workers	-	-	.032 (.018)*	.032 (.018)*
First Move	-	-	-	-.180 (.190)
Second Move	-	-	-	-.150 (.197)
Third Move	-	-	-	-.176 (.224)
First Move*Regional Share HQ	-	-	-	-4.14 (1.31)***
Second Move* Regional Share HQ	-	-	-	-4.21 (1.39)***
Third Move* Regional Share HQ	-	-	-	-3.38 (1.59)**
Fourth Move* Regional Share HQ	-	-	-	-5.04 (1.86)***
Year Dummies	No	Yes	Yes	Yes
Region Dummies	No	Yes	Yes	Yes
Sample	Job Changers within Regions, Sample I	Job Changers within Regions Sample II	Job Changers within Regions Sample II	Job Changers within Regions Sample II
Pseudo R^2	.025	.071	.071	.072
No. of Observations	1,143	10,522	10,522	10,522

Notes: Standard errors in parentheses; ***, **, and * indicate significance at the 1% level, the 5% level, and the 10% level respectively; coefficients for constants are not reported here; coefficients and standard errors of Regional No of Workers as well as of squares thereof are multiplied by 1,000; reference groups for move dummies is '*Fourth or More Moves*'; the education variable equals 0 for '*Degree from a Technical College*' and 1 for '*Degree from a University*'; the variable on a worker's sex equals 0 for '*Male*' and 1 for '*Female*'.

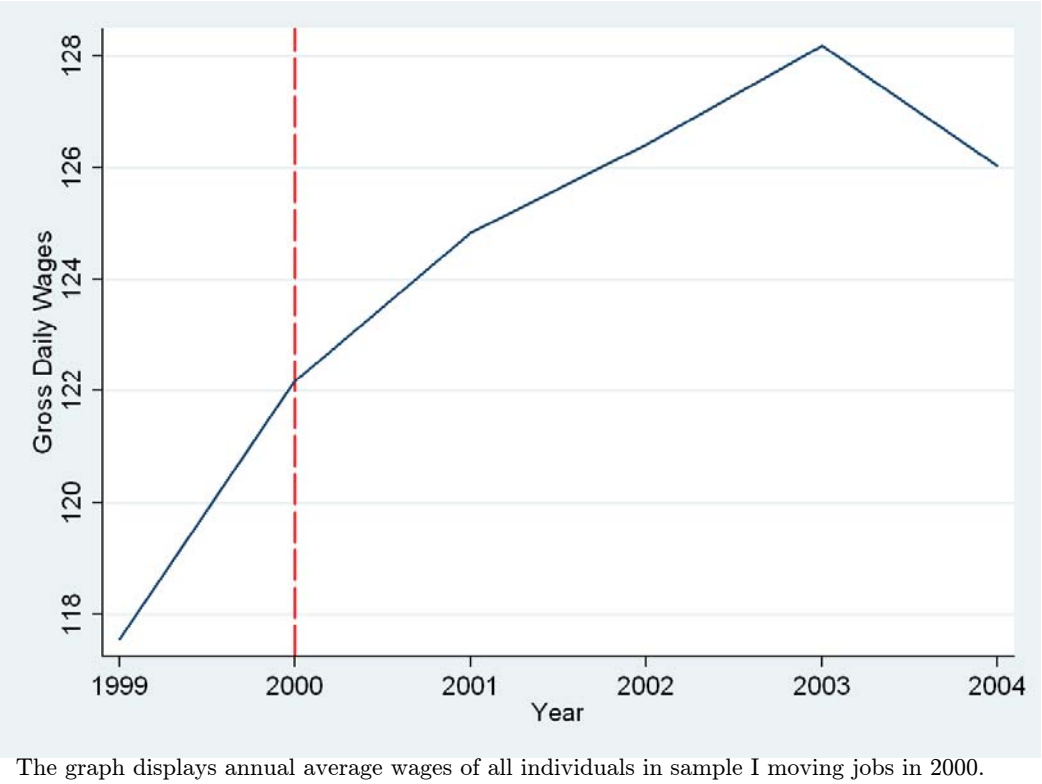
Map I: Average Regional Wages of Highly Qualified Workers, 2001



Map II: Regional Share of Highly Qualified Workers, 2001

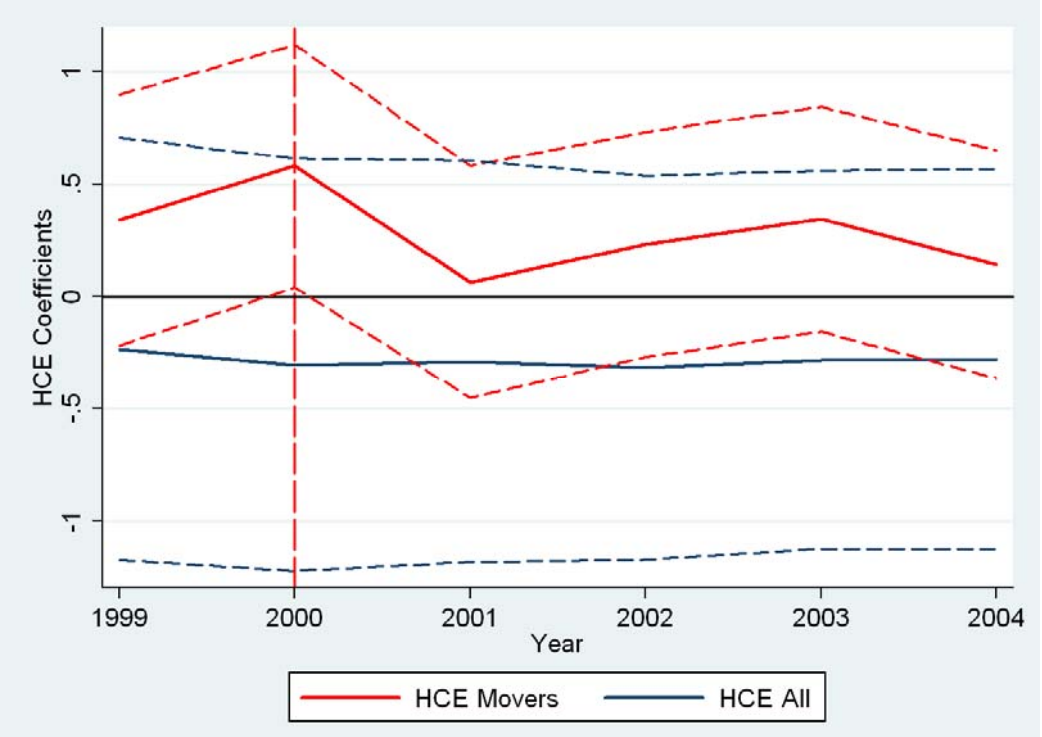


Graph I: Wage Development of Job Movers



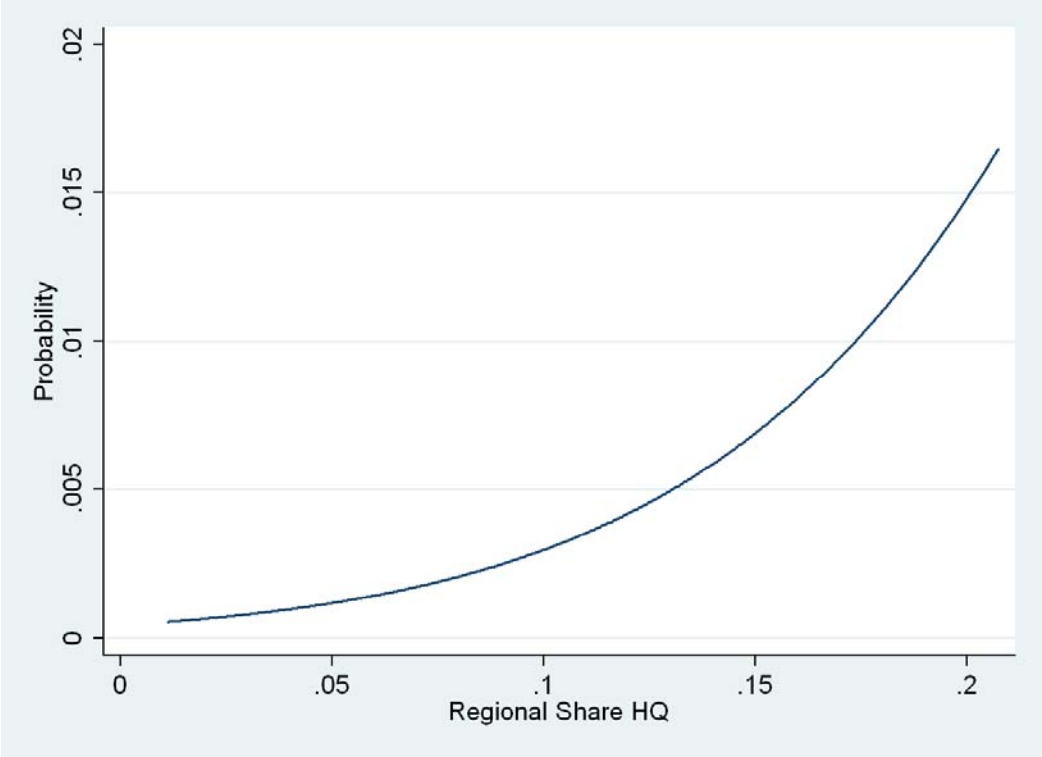
The graph displays annual average wages of all individuals in sample I moving jobs in 2000.

Graph II: Coefficients and Confidence Intervals



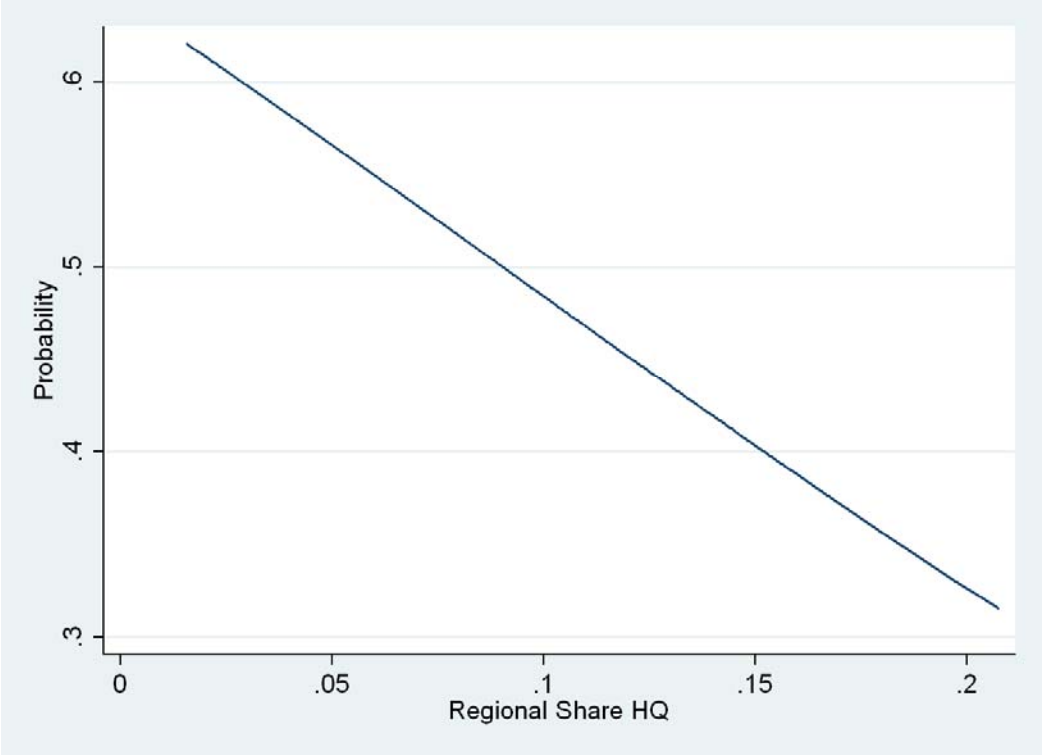
The graph displays the coefficients and the 95 percent confidence intervals of the estimates on the size of general and mover-specific human capital externalities shown in column V in Table I.

Graph III: Probability of Job Change as Function of Regional Human Capital



The graph displays the results from a simulation of job changing probability as a function of regional human capital endowments, based on the results contained in Column IV in Table III.

Graph IV: Probability of Industry Change as Function of Regional Human Capital



The graph displays the results from a simulation of industry changing probability of job changers as a function of regional human capital endowments, based on the results contained in Column III in Table V.