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Reinventing the skilled region: Human capital externalities and industrial change

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**Reinventing the Skilled Region:
Human Capital Externalities and
Industrial Change**

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Reinventing the Skilled Region: Human Capital Externalities and Industrial Change

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Abstract

Bridging the gap between the literatures on industrial change and human capital externalities we investigate the complementarity between aggregate regional education and job turnover. On the level of regional industries in Germany we find strong evidence for such complementarity. Thus, regional human capital turns out to be a crucial ingredient for productivity enhancing industrial change, while human capital externalities arise first and foremost in dynamic labor markets. On the firm level, we find human capital externalities to accrue predominantly to growing firms which benefit from sharing, matching, and learning externalities arising from a large supply of highly qualified workers in skilled, dynamic labor markets. Despite the joint impact of human capital and industrial change on productivity, we find only weak evidence that inter-industry differences the job turnover of highly qualified workers shape the geography of industry location across regions.

Keywords: Human Capital Externalities, Job Turnover, Industrial Change
JEL Categories: D62, J24, R11, R12

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I. Introduction: Human Capital Externalities and Industrial Change

“In all of its period of reinvention, Boston’s human capital has been critical. [...] Boston’s experience certainly suggests that human capital is most valuable to a city during transition periods, when skills create flexibility and the ability to reorient towards a new urban focus.”

Edward L. Glaeser (2005: 122)

Understanding why some regions prosper while others decline has occupied urban and regional economists for centuries (see Duranton 2008). Economic investigations of the matter go back to von Thunen (1826) and Weber (1909), who were the first to provide systematic evidence that transportation costs are among the determinants of the attractiveness of a region as a location for economic activity. While the idea that location and distance matter for the economic fate of regions has regained prominence with the seminal contribution by Krugman (1991), it has been increasingly recognized that with transportation costs falling steadily in the age of globalization there must be more to locational attractiveness than infrastructure alone. It was against this background that Edward Glaeser in the mid-1990s inspired a debate on the role of education as a factor for regional growth. Since then, a burgeoning literature starting with Glaeser/Scheinkman/Shleifer (1995) has provided evidence that a broad human capital base is a crucial ingredient for the success of regions as measured by the growth of regional employment (Simon 1998, Simon/Nardinelli 2003, Shapiro 2006). Based on this insight, a closely related literature argues that skilled regions grow faster because aggregate human capital allows them to efficiently adjust to economic shocks through constant industrial change (Glaeser/Saiz 2003). Consequently, in his enquiry into how Boston managed to not only survive the changing economic tides of history, but even to arise as one of the world’s most thriving cities, Glaeser (2005) emphasizes that it was the broad skill base that allowed the city to frequently adjust to new challenges and to live up to the constant demand for industrial change. While emphasizing the importance of human capital for regional growth, this literature is not very precise on the mechanisms through which human capital allows regions to continuously adjust their industrial portfolio so as to foster growth.

A series of studies inspired by Rauch (1993) investigates the existence of social returns to human capital in greater detail. This literature, which is surveyed in Davies (2002) and Moretti (2004a), employs individual wage equations and shows that productivity enhancing effects from aggregate education are substantial. External effects from human capital have been found to increase productivity within regions and industries alike. Rosenthal/Strange (2008) show that human capital externalities are highly localized and decay with distance, while Kirby/Riley (2008)

provide evidence for the existence of human capital externalities within industries. While quantifying the role of local skills for regional and sectoral productivity, studies in this branch usually do not discuss the importance of labor market dynamics and industrial change for human capital externalities to arise.

In this paper we argue that human capital externalities and productivity enhancing industrial change are, in fact, two sides of the same coin. More specifically, we show that while human capital externalities are a crucial ingredient for industrial change to spur regional growth, external effects from education only arise in dynamic regional labor markets. Surprisingly, this complementarity between aggregate human capital and industrial change has until now not been made explicit.

In this paper we close this gap by analyzing productivity effects from aggregate human capital in a framework of dynamic labor markets. We first survey the two strands of the literature in Section II. We then examine the complementarity between aggregate education and industrial change on three different levels of aggregation. Taking industries within regions as our unit of observation in Section III, we investigate whether regional human capital and job turnover unfold productivity effects only conditional on their joint presence. In Section IV we shift focus to the firm level and analyze whether the size of productivity effects from employment adjustments within firms depend on the local turnover of highly qualified workers. In Section V we finally examine whether the complementarity between industry-specific human capital and job turnover influences the spatial distribution of industries.

Our findings from all three modes of investigation yield strong support for regional human capital externalities and industrial change being highly interdependent phenomena. Thus, productivity benefits from industrial change turn out to be strongest if such change takes place within a skilled environment. Human capital externalities, in turn, yield productivity effects predominantly in local labor markets characterized by high levels of job turnover. Productivity effects from the interplay between human capital externalities and industrial change are reflected on the firm level. We find that growing firm in dynamic labor markets benefit from human capital externalities arising from a large turnover of highly qualified workers. On the industry level, we provide evidence that the dynamics of job turnover differ between industries. Contrary to theoretical expectations, such differences only weakly influence the location decision of firms. In sum, our findings suggest that the interplay between human capital externalities and industrial change increases wages within regional industries, contributes to higher productivity of expanding firms, and, to a minor extent, shapes the geography of industrial location across regions.

II. The Mutual Dependence of Skills and Change: Literature and Data

II.1. The Role of Aggregate Education for Successful Regional Change

The idea that regions are under constant pressure to reinvent themselves goes back to Jacobs (1969), who in *The Economy of Cities* describes in detail the ongoing change of urban industrial composition arising from constant innovation and differences in success therein.¹ Jacobs's insight that regional prosperity can be regarded as a function of successful industrial change has regained prominence recently in theoretical models relating regional growth in employment and income to the underlying industrial composition and especially to changes therein. Duranton (2007) provides empirical evidence that while regions grow or decline rather slowly over time, industries tend to move very quickly between regions. In his theoretical model, which is based on this observation, Duranton relates the direction of city growth to the change of industries between locations and shows that small innovation driven shocks can substantially alter the distribution of industries between regions. The crucial insight from this model is that urban evolutions are the result of constant processes of regional innovation and subsequent industry churning. Similarly, Blien/Sanner (2006) and Desmet/Rossi-Hansberg (2009) argue that the maturity of industries located within a region determines overall regional productivity and employment growth. Since growth prospects of industries decline over time, the success of regions lies in their potential to attract young and growing industries.

If the economic success of regions is, in effect, a function of their ability to change their industrial structure, what determines the potential of a region to constantly reinvent itself through industrial change? Jacobs relates successful industrial change to a broad and diversified mixture of sectors and industries. This idea has, in turn, inspired a large literature on whether industrial diversity is conducive to long-term regional growth. Today, empirical evidence supports the notion of nursery cities developed by Duranton/Puga (2001), i.e. while innovation and the birth of industries take place first and foremost in large, diversified cities, industries tend to disperse geographically over time in order to economize on congestion costs. Glaeser et al. (1992) and Combes/Magnac/Robin (2004) find empirical evidence that industrial diversification is conducive to employment growth, while Henderson/Kuncuro/Turner (1995) show that innovation predominantly takes place in diversified regions (see Duranton/Puga 2000 for a survey of the literature).

¹ On the firm level this idea goes back to Chinitz (1966: 6), who famously states that “in a dynamic economy – i.e. rapid change in technology and demand – a major challenge to entrepreneurship is the conversion of old resources to new uses”.

One of the underlying reasons for the success of regional diversification in fostering innovation and growth is that spatial proximity of different industries allows for more intense spillovers of skills and ideas. Analyzing the location patterns of industries, Ellison/Glaeser/Kerr (2007) show that the tendency of industries to coagglomerate is partly driven by the opportunity to exchange ideas, as evidenced by the intensity of regional technology and patent flows. Similarly, Kolko (2008) provides evidence that the co-agglomeration of service industries is driven by knowledge spillovers between different service sectors. With respect to role of aggregate education, these studies indicate that human capital externalities are more likely to arise in diversified regions, since in such environments industries are more likely to learn from each other and thereby be able to quickly react to new challenges by adjusting production and employment. Accordingly, Fu (2007) refers to diversified, skill intensive cities as 'smart café cities'.

The idea that human capital is a driving force for innovation and change has received attention at least since Theodore Schultz's influential contribution on *The Economic Value of Education*, where with respect to external effects from education he states that "schooling increases the capability of people to adjust to changes in job opportunities associated with economic growth" (1963: 40). Moreover, in line with Nelson/Phelps (1966), Welch (1970: 38) emphasizes that "one dimension of education is the ability to adjust to changing conditions and another dimension may be the ability to innovate". Analogously, employing a model of endogenous growth based on Lucas (1988), Aghion/Howitt (1992) argue that economic growth arises from processes of creative destruction, the intensity of which depends on the size of the skilled labor force. In line with this idea, Faberman (2002, 2007) provides empirical evidence that aggregate job turnover increases with regional human capital endowments, indicating that industrial change and the intensity of adjustment rise with aggregate levels of education. Despite a broad consensus on the importance of human capital for successful industrial change and employment growth, the question of whether aggregate education supports successful industrial change first and foremost in growing or in declining regions has remained controversial. Glaeser/Saiz (2003) argue that a broad human capital base yields benefits first and foremost for declining regions, since it allows for successful industrial change through innovation and thereby over time positively influences the direction of growth. In contrast, Findeisen/Suedekum (2008) find that human capital is a key driver of growth and industrial change only in successful cities, while regional decline is, in contrast, driven by the demise of old industries which can hardly be altered by human capital endowments of whichever intensity.

The studies surveyed so far provide an answer to one of the most fundamental questions within urban economics, i.e. why some regions are successful while others are not, by relating regional success to human capital endowments, which allow for constant regional adjustment through industrial change. This branch of the literature does, however, not provide evidence on the magnitude of external productivity effects from human capital, nor does it shed light on the microeconomic mechanisms through which they arise. Shifting the focus from the regional to the individual level, the literature on human capital externalities addresses the question of how benefits from the local density of human capital come about.

II.2. The Role of Dynamic Labor Markets for Human Capital Externalities

Complementing the literature on the importance of regional human capital endowments for industrial change and regional growth, a series of studies resort to individual wage equations in order to more thoroughly investigate the existence of social returns to human capital. Earlier studies, e.g. by Rauch (1993), argue that increasing average regional levels of education, as measured by the average years of schooling, by one year raises regional wages by five percent due to social returns from education. More recent investigations employing the share of highly qualified workers as a measure of aggregate education show that increasing the share of highly qualified workers by one percent raise aggregate wages by between .4 and 1.9 percent due to external effects from human capital (see Moretti 2004b, Fu 2007).

Studies in this branch of the literature have traditionally associated external effects of human capital with spillovers of technological knowledge. However, there might be more to human capital externalities than the exchange of information on products and processes of production alone. In fact, Duranton (2006) points out that the microeconomic mechanisms through which social returns to human capital come about might be similar to those underlying benefits from agglomeration. Consequently, the class of microeconomic models which explain how productivity benefits arise from economic density can be regarded as a natural starting point for any enquiry into the sources of human capital externalities. Since Duranton/Puga (2004), such models are usually categorized along the lines of sharing, matching, and learning as the core mechanisms through which productivity enhancing agglomeration externalities come about. Analogously, regional human capital can be expected to increase regional productivity through improved opportunities for learning about innovation in products and modes of production, through more efficient matches between workers and firms, and through the sharing of employment risk due to higher worker mobility. We briefly explain these mechanisms in turn.

As argued in the theoretical literature on knowledge transmission, increasing the levels of skills within a population allows for an improved exchange of ideas and thereby increases the potential for innovation and economic growth (Jovanovic/Nyarko 1995). The importance of local human capital endowments for the intensity of knowledge spillovers has been confirmed by a broad empirical literature on the geography of innovation (see Audretsch/Feldman 2004 for an overview). In addition to facilitating the exchange of technical knowledge, aggregate levels of human capital improve the diffusion of information on labor market opportunities and thereby enhance the quality of job matches between workers and firms (Heuermann 2009). In fact, the size of social networks and therewith the efficiency of information diffusion have been shown to increase with individual education (Grossetti 2007). Consequently, human capital externalities through matching arise because aggregate education increases the size of networks and thereby enhances the diffusion of information within local career networks. Finally, firms in regions shaped by higher aggregate education are able to share the risk of employment shocks more efficiently because skilled workers can change jobs between industries more easily than unskilled workers due to a higher level of general skills (Borjas 1987, Chiswick 2005). Having access to a larger stock of highly qualified workers allows firms to efficiently adjust employment to changing levels of demand or productivity and thereby avoid search or vacancy costs. Thus, human capital externalities might arise from an improved intensity of knowledge spillovers, the diffusion of labor market information in dense career networks, and the opportunity of firms to adjust to efficient levels of employment in the face of productivity or demand shocks.

A closer look at these microeconomic mechanisms reveals that the extent to which human capital externalities shape regional wages and productivity is not only a function of aggregate levels of human capital, but also of the intensity of change within regional labor markets. More precisely, job changes of highly qualified workers are a prerequisite for productivity effects from aggregate human capital to unfold. In fact, Saxenian (1994) and Almeida/Kogut (1999) show that knowledge is transferred between firms mostly by workers changing jobs from one firm to another. Thus, knowledge spillovers increase with the churning intensity of highly qualified workers. Likewise, productivity effects from improved labor market matching ultimately depend on the number of workers taking the opportunity to change jobs. In fact, Heuermann (2009) provides evidence that workers in skilled regions not only incur higher wage gains when changing jobs, but also change jobs more often early in life. Finally, benefits from risk sharing in skilled regions arise only if qualified workers are more likely to change jobs between industries and thereby allow firms to adjust employment more efficiently. Providing indirect evidence on risk sharing effects in agglomerated regions, Overman/Puga (2008) show that firms which adjust

employment benefit from the intensity to which neighboring firms adjust employment in the opposite direction. Thus, each of these microeconomic sources requires dynamic local labor markets as a prerequisite for productivity enhancing effects from aggregate human capital to come about.

In what follows we investigate the complementarity between aggregate levels education and dynamic local labor markets on three different levels. After describing the data, we first investigate whether productivity in local industries increases with the joint presence of local human capital endowments and dynamic labor markets. We then analyze whether firms benefit from high levels of job turnover in human capital intensive regions when adjusting employment. On the level of industries, we finally examine whether the prevailing distribution of industries across regions can be explained by differences in intra-industry job turnover of highly qualified workers.

II.3. Data and Descriptive Evidence

All subsequent analyses are based on the Establishment History Panel (BHP) provided by the Institute for Labor and Employment Research (IAB). The BHP is generated by aggregating information on all employees in Germany contained in the Social Security File of the Federal Employment Agency to the establishment level. The resulting dataset covers all establishments in Germany between 1975 and 2005 which employ at least one employee subject to social security contributions (see Spengler 2007 for an overview of the data).² The annual number of establishments in the dataset, defined as a plant or, more generally, a place of work, ranges between 1.5 and 2.5 million.³ For these establishments the dataset contains information on location, industry affiliation, and employment and wage structure, with each variable being observed once a year on the 30th of June. From the annual waves we have generated a panel dataset which allows for tracking establishments over time.

Using information on industrial affiliation we have grouped firms into 18 different sectors, a list of which can be found in Table I along with further information on sectoral employment and payment structures. 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 (Kosfeld/Eckey/Tuerck 2006).

² Although technically we are dealing with establishments throughout the empirical analysis, in what follows we use the terms establishment and firm interchangeably for reasons of simplicity.

³ See Fritsch/Brixy (2004) for a discussion on the definition and classification of establishments.

In all our analyses we measure regional, sectoral, and firm productivity as the average wage of highly qualified workers, defined as those workers holding a degree from either a university or a technical college, rather than as the average wage of all workers. A number of reasons have convinced us to focus on highly qualified workers alone. First, wage setting is more flexible for highly qualified workers, who are less likely to be bound by wage agreements. Focusing on highly qualified workers therefore allows for uncovering regional productivity differences between industries, which are otherwise prone to be suppressed by wage leveling institutional arrangements. Closely related, since we wish to shed light on the importance of change in the labor market, we assume that workers and firms are able to change jobs or employment without such adjustments being delayed, altered, or impeded by labor market institutions. While the German employment protection legislation in principle covers all workers alike, highly qualified workers in practice draw less on such legislation since they usually find it easier to change between jobs. Finally, since Ciccone/Peri (2006) it is well known that imperfect substitutability between highly qualified and non-highly qualified workers might bias estimates on the existence of human capital externalities, because 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 the supply of highly qualified workers increasing over time we are thus prone to overestimate effects from human capital externalities when not differentiating their effects by qualification. Since the primary objective in this paper is to provide first evidence on the interplay between regional change and human capital externalities, we have decided to focus on highly qualified workers alone, well aware that doing so we are likely to underestimate the social returns to education and thereby the joint importance of human capital externalities and job turnover for productivity.

We employ the regional share of highly qualified workers as our preferred measure of regional human capital, rather than average levels of education. Doing so, we follow Krueger/Lindahl (1999) and Moretti (2004b) in their argument that external productivity effects through sharing, matching, and learning are predominantly rooted in the share of highly qualified workers, while external effects from average levels of education unfold predominantly through non-market externalities, such as reductions in crime rates or improved health related behavior.

Maps I and II provide evidence on the close correlation between the regional share 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 endowments follow an imaginary line from the North-West to the South-East.

Heuermann (2008) provides evidence on 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 regional share of highly qualified workers, he shows that while sorting effects play a role for higher wages in skilled 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. In the following analysis we investigate the extent to which dynamic labor markets are a prerequisite for such productivity enhancing effects from aggregate human capital to arise.

III. The Symbiosis between Human Capital and Industrial Change

In this section, we investigate whether the productivity of regional industries rises with the joint presence of industrial change and aggregate human capital. We address this question by examining whether the interaction between human capital endowments and job turnover enhances productivity within regional industries. Equating industrial change with job turnover in regional industries is subject to the assumption that the intensity of industry specific change is reflected in the adjustment dynamics of intra-industry labor markets, i.e. we assume that the extent to which industries change directly translates into employment adjustments.⁴ In line with the existing literature, job turnover is defined as the sum of job creation and destruction within regional industries. Thus, an observed sectoral job destruction rate of ten percent in a regional industry combined with a job creation rate of fifteen percent would imply an overall intensity of change within a regional industry of twenty-five percent. Given our definition, we would obtain the same result with job destruction rate of twenty five and a job creation rate of zero percent. Thus, focusing on the sum of job creation and destruction we generally interpret any type of employment adjustment as being indicative of industrial change without conceptually distinguishing between contraction, expansion, or internal churning of industries. We do, however, for reasons of robustness differentiate between types of adjustments in the course of our empirical analysis below.

In line with Davis/Haltiwanger/Schuh (1996), we define the job creation rate in region r in sector s at time t as the sum of jobs created by all firms i in sector s in

⁴ Although widely used, job turnover is not the only indicator for industrial change. In line with Jovanovic (1982), the turnover of firms is an alternative indicator for the intensity of industrial change (see Santarelli/Vivarelli 2007 for an overview of the literature of industry evolution and firm turnover).

region r at time t as a share of the average employment in sector s in region r between time t and $t-1$.

$$JC_{r,s,t} = \frac{\sum_i \Delta E_{i,r,s,t}^+}{\sum_i \frac{E_{i,r,s,t} + E_{i,r,s,t-1}}{2}} \quad (1)$$

Analogously, we define the region-sectoral job destruction rate as the absolute sum of jobs destroyed by all firms i in region r in sector s at time t as a share of average past and present region-sectoral employment.⁵

$$JD_{r,s,t} = \frac{\sum_i |\Delta E_{i,r,s,t}^-|}{\sum_i \frac{E_{i,r,s,t} + E_{i,r,s,t-1}}{2}} \quad (2)$$

The region-sectoral gross job reallocation rate equals the sum of region-sectoral job creation and destruction weighted by average region-sectoral employment (Davis/Haltiwanger 1992, 1999).

$$GJR_{r,s,t} = \frac{\sum_i |\Delta E_{i,r,s,t}^-| + \sum_i \Delta E_{i,r,s,t}^+}{\sum_i \frac{E_{i,r,s,t} + E_{i,r,s,t-1}}{2}} \quad (3)$$

Graph I to V provide evidence on the size and evolution of national, sectoral, and region-sectoral change intensity. Graphs I and II map the dynamics of job turnover on a national level showing that with about twenty-five percent of jobs being created or destroyed, annual job turnover within the labor market for highly qualified workers in Western Germany is substantial. Expressed in absolute numbers, more than 350,000 of about 1.4 million jobs held by highly qualified workers were turned over in 2003. Of these, about four fifth are reallocated between firms, while the remaining one fifth is due to net job creation. While net job growth has remained roughly constant over time with about 50,000 jobs newly created per year, excess turnover has tripled from about 120,000 jobs being reallocated between firms in 1977 to 350,000 jobs in 2003. Thus, job reallocation between firms is about seven times larger than annual net job growth in 2003. Graph III shows that the bulk of job churning takes place in existing establishments, which create and destruct nearly twenty percent of overall highly qualified employment, i.e. about 280,000 jobs, each year.⁶ This number is distinctly smaller for start ups, closing firms, and up- and

⁵ For reasons of brevity and in order to avoid unnecessary repetition we refer to job creation, destruction, and reallocation in region r in sector s at time t from now on as *region-sectoral* job creation, destruction, and reallocation.

⁶ We define existing establishments as those which have already employed highly qualified workers in the past period and continue to do so in the present period; upgrading firms have already existed in the past period, but employ highly qualified workers for the first time in the present period;

downgrading firms, which together turn over about five percent of national employment of highly qualified workers, i.e. about 70,000 jobs, annually.⁷ Graph IV reveals that job turnover not only differs substantially between sectors, but that these differences are stable over time. While most sectors exhibit shock intensities between fifteen and thirty percent, annual job turnover rates in Retail, Consumer Services, and Legal and Economic range well beyond forty percent. Finally, Graph V shows that region-sectoral job creation and destruction rates are positively correlated, implying that the bulk of job churning takes place within regional industries, rather than between them (see Baldwin/Dunne/Haltiwanger 1998). Given our theoretical considerations, these numbers raise the question of whether productivity effects from job reallocation depend on the density of human capital within local or sectoral labor markets. With each job being turned over every four years on average there is clearly room for theoretical arguments that firms and workers benefit from high levels of local human capital by reaping gains from sharing, matching, and learning.

To investigate the complementarity between human capital and industrial change we estimate average productivity within a regional industry as a function of the intensity of job reallocation, human capital endowments, as well as their interaction.

$$w_{r,s,t} = \beta_1 HC_{r,s,t,k} + \beta_2 GJR_{r,s,t,k} + \beta_3 HC_{r,s,t,k} \times GJR_{r,s,t,k} + \beta_k X_{r,s,t,k} + \beta_m Z_{r,t,m} + \phi_r + \phi_s + \phi_t + \varepsilon_{r,s,t} \quad (4)$$

More specifically, we regress average wages w in region r in sector s at time t on the share of highly qualified workers, HC , on the job reallocation rate, GJR , on the interaction between human capital intensity and change, as well as on a number of region-sectoral and regional characteristics, X and Z . On the region-sectoral level we control for average firm size, which has frequently been shown to be related to average wages (Green/Machin/Manning 1996). In addition, we control for agglomeration effects within both regions and regional industries by including the respective numbers of highly qualified workers. In order to account for entity and time invariant factors we employ region, sector, and time fixed effects. Our coefficient of interest is β_3 , which we expect to be significantly positive if productivity effects of regional change and regional human capital are complementary, i.e. arise conditional on their joint presence. For results on the interaction term to be consistent, no variables should exist which are correlated with either industrial change or human capital and unfold productivity effects conditional on the presence of the respective

downgrading firms have employed highly qualified in the last period but ceased to do so in the present period; start-ups/closures start/cease to exist, creating/destroying highly qualified employment (see Boeri/Cramer 1992 for a comparison of differences in growth between incumbents and start-ups).

⁷ Disaggregating gross job turnover into job creation and job destruction by firm type clearly shows that existing firms are the drivers of employment growth, defying Birch's (1987) notion that small start-ups create the lion's share of jobs.

other one. For reasons outlined below, we control for the interaction between the regional rate of unemployment and job turnover as a potentially confounding factor. Doing so, we are confident that despite its ad-hoc nature, this equation lives up to our objective of providing first evidence on the complementarity between aggregate human capital and industrial change. Scrutinizing the robustness of our findings we further investigate this complementarity on the firm level in Section IV.

Table II contains our results. In columns I to IV we estimate equation (4) taking industries within regions as our unit of observation. In column V we focus on the level of overall regions rather than on single industries. Our dependent variable throughout all regressions is the average productivity of highly qualified workers. For reasons of clarity we have grouped the independent variables into four categories. The results on the interaction between job turnover and aggregate human capital are contained in the category *'Skills and Change'*. Results for unconditional effects from both variables are contained in the categories *'Change'* and *'Skills'*. Control variables are contained in *'Controls'*. We comment on the results within each category in turn.

As our core result, we find strong evidence for significantly positive productivity effects from the joint presence of regional change and human capital endowments, which are subject to negative marginal returns. In fact, all interaction effects between the share of highly qualified workers and the intensity of job turnover are positive and highly significant, while their squares turn out significantly negative. More specifically, the coefficient on the interaction term in column II indicates that raising the share of human capital within a regional industry by one standard deviation, i.e. by about ten percent, increases wages by about two percent conditional on an average job turnover rate of 25 percent. Conversely, raising average job turnover by one standard deviation, i.e. by 13 percent, increases wages by about one percent, conditional on an average level of human capital of about eleven percent.

In column III we analyze whether complementarities between industrial change and aggregate human capital mainly occur on the level of regional industries, or on the level of regions. We therefore interact the region-sectoral job turnover with the share of highly qualified workers within a regional industry and within a region, respectively. We find that regional industries not only benefit from their own human capital endowments in times of change, but even more so from the share of highly qualified workers on the regional level. This result indirectly supports the notion that industries in diversified regions are more productive because they benefit from sharing one regional labor market with other industries. In fact, finding the complementarity between aggregate human capital and industrial change to be more pronounced on

the regional level than within local industries suggests that highly qualified workers change jobs between industries more often in skilled regions and thereby allow for external productivity benefits from improved opportunities for matching, sharing, and learning to arise.

The last two columns contain further robustness checks. In column IV we control for nonlinearities in the interaction terms. While the significantly negative coefficients on the quadratic interaction terms evidence marginally decreasing joint effects, the overall joint effect remains positive over the whole range of existing values for turnover and human capital. In column V we examine whether productivity effects found within regional industries also arise within regions. We therefore exchange our dependent variable, i.e. average productivity on the region-sectoral level, with its equivalent on the regional level. Again, the complementarity between human capital and job turnover turns out to be more pronounced on the regional level. This finding emphasizes that in line with Jacobs (1969) the success of regions does not depend on aggregate human capital and industrial change within single industries alone, but rather on the overall sectoral composition of regions and the constant exchange of highly qualified workers between industries.

The unconditional effects of job turnover and human capital on both sectoral and regional productivity turn out to be negative. With respect to industrial change, this indicates that employment reallocation within industries is not in and by itself productivity enhancing. Two reasons come to mind. First, job turnover is likely to entail the loss of firm-specific human capital. Secondly, with the overall number of highly qualified workers increasing by about five percent annually, overall job turnover is partly driven by the net creation of highly qualified employment. This net creation is likely to depress wages through supply effects and through a generally lower labor market experience of young workers. Negative coefficients on the share of highly qualified workers, in turn, indicate that productivity enhancing effects from human capital predominantly arise through labor market dynamics, while overall levels of human capital first and foremost unfold static amenity effects, which in turn depress wages (see Moretti 2008). Alternatively, negative effects from aggregate human capital might result from supply effects rooted in the imperfect substitution between highly qualified and non-highly qualified workers discussed above.

Our control variables display the expected signs and are of a meaningful size. In general, average wages rise with average firm size per sector, as well as with the overall number and the number of highly qualified workers in a sector. In columns II to V we have additionally controlled for wage curve effects, as well as for potential interaction effects between job turnover and region-sectoral unemployment. The

latter is inspired by Moretti (2000), who argues that workers are compensated for the risk of becoming unemployed. Since the risk of becoming unemployed is a function of overall levels of unemployment and job turnover, we include the interaction between both in our equations.⁸ We find evidence for wage curve effects and risk compensation on the regional level. Since a detailed investigation of such insurance effects is beyond the scope of this paper, we leave it for further research.

In Table III we address the question raised by Glaeser/Saiz (2003), i.e. whether aggregate human capital and industrial change yield productivity effects independent of the direction of industrial growth. As outlined above, while with respect to Germany Findeisen/Suedekum (2008) show that education unfolds external effects only in expanding sectors, Glaeser/Saiz (2003) provide evidence for the US that human capital is especially helpful in times of sectoral decline. In Columns I to V we re-estimate equation (4), employing net job creation and destruction rates, excess churning rates, and positive and negative job growth rates as indicators for different types of industrial change. Human capital effects turn out to be largest in industries characterized by high rates of excess churning, i.e. if jobs are allocated intensely between firms within a sector, and in industries exhibiting positive job growth and job creation rates. In contrast, we find only small positive effects for industries shaped by high rates of job destruction, and no significant effects from aggregate human capital in declining industries. In line with Findeisen/Suedekum (2008) our results suggest that human capital and job turnover are most productively combined in dynamic sectors displaying an overall tendency to grow. Analogous to our analysis above, we find productivity effects from aggregate human capital to be larger on the regional compared to the region-sectoral level.

We draw two preliminary conclusions from our results obtained so far. First, neither industrial change nor regional human capital endowments yield productivity effects in and by themselves. Rather, while successful industrial change necessitates the presence of aggregate human capital, human capital externalities themselves come about only through workers changing firms in dynamic labor markets. Secondly, joint productivity effects from human capital and industrial change primarily depend on aggregate levels of education within regions, rather than within regional industries alone, supporting Jacob's (1969) idea that a broad skill base and a diversified industry structure allows regions to constantly and successfully reinvent themselves.

⁸ We thank Oliver Fabel for pointing out the necessity to control for insurance effects in the face of high rates of both regional unemployment and job turnover.

IV. Human Capital Externalities and Change on the Firm Level

In this section, we wish to corroborate our findings on the complementarity between industrial change and human capital on the firm level by examining whether firms benefit from being located in dynamic and skilled regions when adjusting their employment of highly qualified workers. Our presumption is that if improved opportunities for sharing, matching, or learning exist in skilled, dynamic labor markets, growing firms should incur productivity effects predominantly in regions shaped by a large supply of highly qualified workers.

An example clarifies the idea. Imagine a firm wishes to increase production due to a positive productivity shock by recruiting highly qualified workers. With the existence of local human capital externalities we should find growing firms to benefit from the extent to which neighboring firms reduce their employment, since this allows them to easily find a qualified match (matching externality), to obtain potentially relevant knowledge from neighboring firms (learning externality), and to benefit from lower adjustment costs due to a larger supply of highly qualified workers in shared labor markets (sharing externality).

Based on this idea, we examine whether the productivity of firms which adjust employment is influenced by the intensity to which other firms within the same industry adjust employment in the opposite direction. We therefore define two indicators for the overall adjustment trends within a regional industry, as well as two indicators of the extent to which firms develop either parallel with, or against this trend. We take the absolute value of the region-sectoral growth rate (GR) as indicator for the intensity of employment adjustment within a regional industry.

$$GR_{r,s,t} = \left| \frac{\sum_i E_{i,r,s,t}}{\sum_i E_{i,r,s,t} + \sum_i E_{i,r,s,t-1}} \right| \quad (5)$$

Firms can adjust employment either in line with the overall growth trend of an industry, i.e. expand (reduce) employment in growing (declining) industries, or can develop diametrically. We therefore define one indicator for the intensity to which a firm grows in line with its industry. Our indicator for sector-congruent employment adjustment (SCA) equals the growth rate of a firm if it grows into the same direction as its regional industry, and takes on a value of zero otherwise.

$$SCA_{i,t} = \begin{cases} \left| \frac{E_{i,t}}{E_{i,t}+E_{i,t-1}} \right| & \text{if } \text{sign}\left(\frac{E_{i,t}}{E_{i,t}+E_{i,t-1}}\right) = \text{sign}(GR_{r,s,t}) \\ 0 & \text{if } \text{sign}\left(\frac{E_{i,t}}{E_{i,t}+E_{i,t-1}}\right) \neq \text{sign}(GR_{r,s,t}) \end{cases} \quad (6)$$

Conversely, our indicator for sector-adverse employment adjustment (SAA) measures the deviation of individual firm growth from the growth trend of its regional industry. It is defined as the sum of absolute values of firm level growth and region-sectoral growth if both show opposite signs. If a firm grows into the same direction as the regional industry, the SAA takes on a value of zero. Since a firm can adjust employment only into one direction within a given year (if it grows at all), the SCA and the SAA can never both be different from zero at the same time for one firm.

$$SAA_{i,t} = \begin{cases} \left| \frac{E_{i,t}}{E_{i,t}+E_{i,t-1}} \right| + \left| \frac{\sum_i E_{i,r,s,t}}{\sum_i E_{i,r,s,t} + \sum_i E_{i,r,s,t-1}} \right| & \text{if } \text{sign}\left(\frac{E_{i,t}}{E_{i,t}+E_{i,t-1}}\right) \neq \text{sign}\left(\frac{\sum_i E_{i,r,s,t}}{\sum_i E_{i,r,s,t} + \sum_i E_{i,r,s,t-1}}\right) \\ 0 & \text{if } \text{sign}\left(\frac{E_{i,t}}{E_{i,t}+E_{i,t-1}}\right) = \text{sign}\left(\frac{\sum_i E_{i,r,s,t}}{\sum_i E_{i,r,s,t} + \sum_i E_{i,r,s,t-1}}\right) \end{cases} \quad (7)$$

We finally define an indicator for the average intensity to which firms within a regional industry develop against the sectoral trend. We define this average adverse growth rate (AGR) as the mean sector-adverse adjustment rate within an industry. This indicator measures the average intensity to which N firms in region r in sector s at time t adjust employment opposite to the growth trend of their regional industry.

$$AGR_{r,s,t} = \frac{\sum_i SAA_{i,t}}{N} \quad (8)$$

Based on these indicators we examine whether growing firms are more productive through improved opportunities for sharing, matching, and learning in regional industries which are shaped by a large availability of highly qualified workers. An increased local supply of highly qualified workers can arise from two scenarios. On the one hand, firms expanding employment of highly qualified workers in line with their regional industry, i.e. display non-zero SCA, are expected to benefit from the intensity to which other firms reduce their employment of highly qualified workers against this overall trend, i.e. from the size of the AGR. Conversely, firms which grow while their local industry declines in terms of highly qualified employment, i.e. which display a non-zero SAA, should incur productivity benefits from the intensity of local industrial decline.

Investigating the productivity consequences of these two types of adverse adjustments dynamics between firms and their local industries, we estimate equation (9), which

expresses the average wage in firm i at time t , $w_{i,t}$, as a function of the interactions between region-sectoral growth and sector-adverse firm adjustment, and between average adverse adjustment and sector-congruent firm growth.

$$w_{i,t} = \beta_1(GR_{r,s,t} \times SAA_{i,t}) + \beta_2(AGR_{i,t} \times SCA_{r,s,t}) + \beta_3 GR_{r,s,t} + \beta_4 SCA_{i,t} + \beta_5 SAA_{i,t} + \beta_6 AGR_{r,s,t} + \gamma_k Z_{k,i,t} + \phi_i + \phi_r + \phi_s + \phi_t + \varepsilon_{i,t} \quad (9)$$

β_1 and β_2 provide evidence on whether human capital externalities arise from the interplay between firm-level employment adjustments and the availability of highly qualified workers within regional industries. A significantly positive coefficient β_1 indicates that productivity benefits accrue to growing firms in regional industries which decline in terms of highly qualified employment. Conversely, a significantly positive coefficient β_2 provides evidence that firms which in line with their regional industry exhibit positive growth rates benefit from the intensity to which other firms shed highly qualified workers. Significant coefficients of either type reinforce the notion that the reallocation of highly qualified workers between firms provides the basis for productivity effects from human capital to arise on the microeconomic level.

In order to control for unconditional productivity effects from employment adjustment on the firm and industry level, we include each of our four indicators separately. Since wages increase with firm size and with the level of qualification within a firm, we also control for total employment, as well as for the share of highly qualified workers within a firm (see Holmes/Stevens 2002). In order to control for factors which are constant across time or entities we include region, sector, time, and firm fixed effects. As in Section III, our identifying assumptions is that no variables exist which are correlated with firm-level (region-sectoral) employment adjustment and unfolds productivity effects conditional on region-sectoral (firm-level) employment dynamics. While we cannot completely rule out the possibility that such variables exist, we deem this approach suitable to complement the evidence obtained in Section III and to provide first evidence on the role of firm level and region-sectoral employment adjustment dynamics for human capital externalities to arise.

We estimate equation (9) on different subsamples. Comparing the effects for firms which expand employment to those which reduce employment, we examine whether in line with our theoretical expectations interaction effects are driven first and foremost by growing firms. In addition, estimating the equation separately for growing and declining sectors allows us to control for wage effects arising from differences in labor supply and demand within regional industries.

Table IV contains our results. For reasons of clarity we have again grouped the independent variables into three categories. The first category, '*Adverse Change*', provides results on the interaction terms. The categories '*Industrial Change*' and '*Controls*' contain unconditional wage effects from firm and industry level employment adjustments, as well as results on further control variables. In the first column we have estimated equation (9) using the full sample of firms. Columns II to V display our results obtained from different subsamples of sectors and firms.

Results within the category '*Adverse Change*' reveal a clear-cut pattern. Significantly positive coefficients in column I provide evidence that the productivity of firms which adjust employment increases with the intensity to which other firms adjust their employment in the opposite direction. Columns II and III show that such productivity effects from adverse adjustment are entirely driven by growing firms. This finding is in line with our theoretical proposition that human capital externalities accrue mainly to growing firms which benefit from sharing, matching, and learning externalities rooted in the improved local availability of skilled workers.

The first line in column II shows that if firms grow with their industry by an annual average of seventeen percent, increasing the average adverse adjustment intensity by one standard deviation, i.e. by five percentage points, is associated with .1 percent higher wages. Conversely, increasing firm growth by one standard deviation, i.e. by about forty percentage points, raises average wages of highly qualified workers by .6 percent, given an average region-sectoral adverse adjustment intensity of thirteen percent. Since in order to avoid further complication we do not control for productivity effects which arise only over time, the wage gains observed here are likely to be incurred predominantly by job changers. Given this reasoning, our results suggest that human capital externalities raise wages of those seventeen percent of workers who start jobs in growing firms by .5 percent on the incidence of job change.

The second line in column I shows that similar effects can be found for firms which grow against the trend of their local industry. However, comparing both results reveals that productivity gains from adverse adjustments are significantly larger for firms which grow with their industry, than for those growing against it. Since there is no theoretical reason why human capital externalities should accrue differently to either type of firm, we suspect that differences in labor supply and demand within regional industries might drive our results.

In Columns IV and V we therefore estimate equation (9) separately for growing and declining sectors. We find only minor differences. In fact, whenever firms grow, they

benefit from adverse adjustments of their regional industry. For shrinking firms, in contrast, we find no effects in Column IV and rather small effects in Column V. In general, the results in Table IV indicate that productivity effects from the interaction between firm growth and adverse employment adjustment within regional industries arise for growing firms independent of whether they grow with their sector or against it. Thus, while we are unable to explain why human capital effects are of a different size for the two types of firms, our results do not differ between growing and contracting sectors and are thus unlikely to be driven by supply and demand effects.

Before interpreting this result in the light of the interdependence between human capital and industrial change, the coefficients on unconditional effects from industry and firm level adjustments, as well as on further controls deserve brief mentioning. We find both industry and firm turnover to be negatively related to firm productivity. In line with our argumentation from Section III, we relate negative productivity effects from aggregate change within regional industries to an overall loss of firm specific human capital. The same argument holds for negative effects from firm-specific turnover, which brings about lower levels of firm- or industry-specific human capital and, given an increasing supply of highly qualified workers, a higher average number of young, inexperienced workers within firms. The results on further control variables are in line with our expectations. Cubic specifications of firm size and firm-specific human capital endowment showed the best fit, indicating that both are correlated with higher average firm wages.

Summing up, our results provide evidence that growing firms are more productive when having access to highly qualified workers within dynamic and skilled labor markets, suggesting that human capital externalities arise from the intensity of employment adjustment in skilled regions. This result, which emerges consistently across different growing and declining sectors, corroborates the complementarity between aggregate education and industrial change identified in Section III. In fact, finding significantly positive interaction effects between firm growth and adjustment dynamics within regional industries supports the idea that the local environment within which firms adjust their employment of highly qualified workers is crucial for productivity enhancing effects from human capital externalities to arise. More specifically, our findings suggest that skilled and dynamic regional industries enable firms to benefit from efficient matches, facilitated knowledge spillovers, and from shared labor markets across industries.

V. The Intensity of Change and the Geography of Industrial Location

Our results obtained so far suggest that productivity enhancing external effects from aggregate human capital come about through highly qualified workers changing jobs in dynamic local labor markets. This raises the question whether firms strategically choose their location so as to benefit from a high local turnover of highly qualified workers. In this section we therefore examine whether differences in job turnover intensities between industries shape the geography of industrial location in Germany.

Based on our result from Section IV, i.e. that firms incur productivity benefits if they have access to dynamic local labor markets, we expect firms within one industry to coagglomerate if they display a high variance of employment adjustment. Conversely, industries exhibiting a low variance of firm growth should be more dispersed geographically in order to reap the gains from regional diversification, i.e. to allow firms to exchange highly qualified workers with firms of other local industries. Hence, the core hypothesis we examine here is whether the potential of firms within one industry to exchange highly qualified workers shapes their propensity to cluster. We test this proposition by investigating whether the extent to which firms adjust their employment parallel to other firms in their sector influences the size of regional industries, as well as the overall concentration of an industry.

We first analyze whether we find evidence that regional industries with a high potential to exchange highly qualified workers between firms are larger on average. As a measure for the potential to exchange highly qualified workers we take the average adverse growth rate defined in expression (8), i.e. the mean growth rate of firms adjusting employment against the trend of their regional industry. In addition, we examine whether regional industries tend to be smaller with a propensity of firms to grow into the same direction. Being located in a relatively small industry allows firms to share one labor market of skills with other industries. As our measure for the homogeneity of employment adjustment we take the average sector-congruent growth rate (CGR) which measures the extent to which all N firms in region r in sector s at time t adjust employment into the same direction as the regional industry.

$$CGR_{r,s,t} = \left| \frac{\sum_i SCA_{it}}{N} \right| \quad (10)$$

We use the total employment of a regional industry, as well as its employment share within a region, as alternative measures for the size of a regional industry S , which we estimate as a function of average sector-congruent (CGR) and sector-adverse growth rates (AGR), including region, sector, and time fixed effects as controls.

$$S_{r,s,t} = \beta_1 CGR_{r,s,t} + \beta_2 AGR_{r,s,t} + \phi_r + \phi_s + \phi_t + \varepsilon_{i,t} \quad (11)$$

Results from estimating equation (11), which are contained in columns I and II in Table V, are consistent for both measure of regional industry size. In fact, we find the size of regional industries to increase with the intensity of average sector-adverse growth, indicating that large industries are shaped by a more intense exchange of highly qualified workers between firms. In general, increasing the intensity of adverse growth by one standard deviation, i.e. by four percent, is associated with a rise in the regional employment share of an industry by about one percent, as well as with a rise in total employment within a cluster by slightly above ten highly qualified workers. While these findings by their nature remain suggestive and have nothing to say about causality, they support the suspicion that patterns of industrial agglomeration emerge from firms reaping the gains from intra-industry change.

In what follows we wish to corroborate this idea by investigating whether a correlation exists between the regional concentration of industries and the dynamics of industrial change. We use the Ellison-Glaeser-Index (Ellison/Glaeser 1997) as our measure of industrial concentration. The Ellison-Glaeser-Index (EGI) measures the extent to which industry s is regionally concentrated at time t and is defined as

$$EGI_{s,t} = \frac{G_{s,t} - (1 - \sum_r (E_{r,t}/E_t))H_{s,t}}{(1 - \sum_r (E_{r,t}/E_t))(1 - H_{s,t})} \quad (12)$$

G represents the spatial Gini coefficient of industry s . It is constructed by taking the squared sum of the differences between relative national employment in region r and relative sectoral employment in region r across all regions. G equals zero if employment in sector s is distributed across regions in exactly the same way as overall employment, and takes on a value close to one if a sector is concentrated within one region.

$$G_{s,t} = \sum_r \left[\frac{E_{r,t}}{E_t} - \frac{E_{s,r,t}}{E_{s,t}} \right]^2 \quad (13)$$

Unfortunately, the Gini coefficient does not adequately differentiate between true sectoral clustering on the one hand, and the intensity to which employment is clustered due to differences in the size of firms and regions. By means of an example, if all employment within a sector is concentrated within one firm, it is not surprising to find sectoral employment to be concentrated within one region. This concentration is, however, due to employment being concentrated in a firm, and not to unique

sectoral agglomeration. The EGI corrects for regional size and employment clustering among firms by including relative region size and the Hirschman-Herfindahl index H of employment concentration between plants i within one sector into the index.

$$H_{s,t} = \sum_i z_{i,t}^2 \quad (14)$$

The EGI rises with the extent to which sectoral clustering deviates from a random distribution of sectors under a given distribution of firm and region sizes. Although inherently ad hoc, Ellison/Glaeser (1997) propose the following classification of sectors with respect to their concentration: a range between .2 and .5 for the sector-specific EGI indicates sectoral concentration, with an EGI exceeding .5 pointing to high sectoral concentration. Sectors with an EGI below .2 are regarded as not being concentrated at all, with negative values of the EGI indicating excess dispersion.

Graph VI contains the evolution of sectoral concentration in Western Germany. The two most striking observations emerging from the graph are the low degree of concentration of Western German industries on the one hand, and the relative stability of intra-sectoral concentration, which is in line with findings by Suedekum (2006). Out of 18 industries only four qualify as being concentrated. Disregarding Agriculture/Fishing/Mining, which is by definition concentrated around natural resources, and Transportation, the concentration of which is to a large extent rooted in the nature of ports and airports as indivisible goods, only the Iron and Steel Industry and the Insurance and Banking Sector display a certain extent of concentration with the former moving towards more dispersion, and the latter towards increased concentration.

In order to test whether sectoral differences in the dynamics of industrial change contribute to differences in sectoral concentration we regress the EGI on the sectoral means of sector-congruent and sector-adverse shock intensity and include sector size, as well as time and sector specific fixed effects as further controls.

$$EGI_{s,t} = \varphi_1 CGR_{s,t} + \varphi_2 AGR_{s,t} + \varphi_3 Empl_{s,t} + \phi_t + \phi_s + \varepsilon_{s,t} \quad (15)$$

If the sectoral dynamics of labor market adjustments shaped the geography of industrial location, we should find industries characterized by larger sector-adverse growth to be more concentrated in order to reap the benefits from intra-industry churning. Conversely, with increasing sector-congruent adjustments firms should tend to disperse regionally so as to benefit from the exchange of jobs with other industries. With these considerations in mind we would interpret a significantly negative

coefficient φ_1 , and a significantly positive coefficient φ_2 , as evidence that the dynamics of firm growth within industries, i.e. the extent to which firms differ in their direction of growth and thereby churn jobs within industries, or to which they all grow in line with their industry, is correlated with the geography of industrial location.

Column III in Table V contains the results of estimating equation (15). In line with our expectations, φ_1 is significantly negative, implying that sectors with large sector-congruent employment adjustments are more dispersed. The coefficient is, however, rather small with an increase in average sector-congruent shocks by one standard deviation, i.e. by about five percent, reducing the EGI by .001. Findings are even weaker for average sector-adverse growth. While φ_1 shows the expected sign, it is smaller and not significant. Thus, while there is some indication for a correlation between the dynamics of intra-industry employment adjustment and the concentration of industries, the size of such effects is rather small.

Summing up, the results in Table V provide preliminary evidence on the interplay between sectoral adjustment and the geography of industries. In general, we find indication for the industry-specific dynamics of labor market adjustments to be correlated with regional industry size and overall sectoral concentration. The negligible size of this connection is, however, in line with the general insight that the distribution of industries across German regions is rather stable, i.e. there is inherently low change in the geography of industrial location. Finding the dynamics of skilled labor markets to be only of minor importance for the spatial distribution of industries emphasizes the multitude of factors affecting location decisions of firms, among which the benefits from human capital externalities play only a moderate role.

VI. Conclusion

Inspired by the literatures on industrial change and on social returns from human capital we examined the joint importance of human capital endowments and job turnover for regional prosperity. While the two literatures share the same object of study, i.e. the sources of regional productivity and growth, they have so far developed rather separately. Since we regard the complementarity of aggregate human capital and dynamic labor markets as the missing link between the two branches, we investigated whether productivity effects arise from the joint presence of aggregate education and high local intensities of job turnover. Three insights emerged.

First, we find strong evidence for the complementarity of aggregate human capital and industrial change. More specifically, while productivity enhancing regional change is more likely to occur in human capital rich regions, social returns to human capital necessitate dynamic labor markets to come about. In line with Suedekum/Findeisen (2008), we find productivity effects from the joint presence of industrial change and aggregate education to be most pronounced in growing industries.

Secondly, our findings on the microeconomic level support the notion that human capital externalities come about through industrial change within local labor markets. Specifically, we found productivity in growing firms to rise with the local supply of highly qualified workers, indicating that firms expanding employment in dynamic and skilled regions benefit from efficient labor market matches, from knowledge embodied in workers changing firms, and from the mobility of workers between industries.

Thirdly, despite the joint importance of industrial change and local human capital for productivity effects to arise, we find only weak indication that industry-specific labor market dynamics shape the geography of industrial location. The small size of these effects emphasizes the persistence of regional industrial patterns, as well as the multitude of factors influencing the location decision of firms.

Two lessons arise from our findings for the design of regional policies. The first lesson is that in order to keep up with the demand to constantly reinvent themselves, regions and firms both rely on dynamic regional labor markets and on local human capital endowments. Any policy committed to enhancing long-term regional prospects is therefore well advised to bear in mind that a diversified and dynamic industry structure and a skilled workforce are equally important conditions for successful industrial change. Given the importance of labor market dynamics, fostering the development of a large number of small, innovative firms might be more beneficial than attracting a single large firm alone. This insight is very much in line with Saxenian (1994), who argues that the decisive reason for why the computer industry in Silicon Valley is more successful than in Boston's Route 128 region is its large number of small, innovative firms, which allows each firm to adjust more efficiently to industrial change than the small number of large corporations can in Boston. The second lesson is that this combination yields productivity effects predominantly in growing regional industries. In line with the literature on the life cycles of industries, in declining regions it might therefore be more promising to actively support the development of young, innovative industries which allow for regional reinvention, rather than to expect the combination of human capital and intense labor market turnover to bring about productivity enhancing industrial change.

Two questions remain for further research. First, given the importance of aggregate human capital for regional productivity, furthering our understanding of the microeconomic foundations through which human capital externalities arise is clearly desirable. So far, existing studies provide strong support for the notion that regional education facilitates the diffusion of technological knowledge. Insights into the relative importance of matching and sharing externalities have remained, in contrast, rather vague. Closely related to issue of how productivity growth in skilled regions comes about is the question of how aggregate education translates into improved opportunities for successful regional change. In this respect, understanding the role of human capital for innovation and the inter-sectoral transmission of knowledge, as well as for entrepreneurship and the dynamics of firm growth is clearly needed. Addressing these issues, the empirical literature inspired by Acs/Audretsch (1988) and Audretsch/Feldman (1996) provides a welcoming starting point in order to investigate the role of human capital, innovation, and entrepreneurship in growing and in declining industries, respectively.

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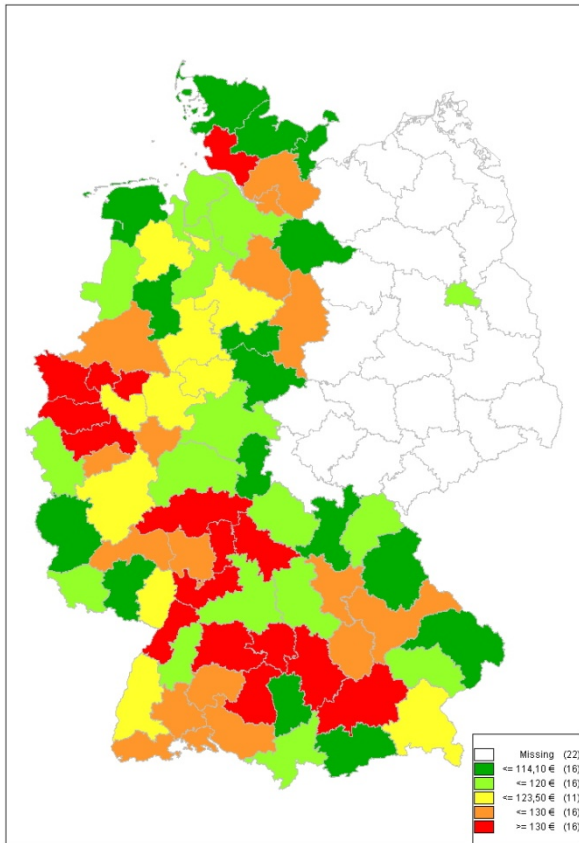
Appendix

Table I – Industry Classification and Employment Characteristics

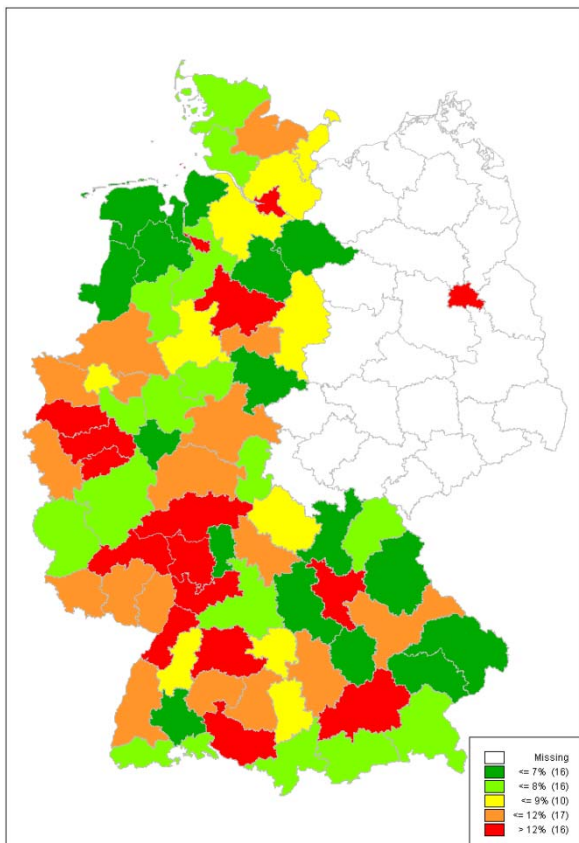
	Average Wages of Highly Qualified Workers	Employment of Highly Qualified Workers
Chemical Industry	121.79	87,912
Insurance and Banking	119.46	81,000
Mechanical Engineering	117.02	162,813
Iron and Steel Industry	116.87	17,022
Electrical Engineering	116.48	167,236
Food Production and Processing	105.66	11,952
Public Sector	103.42	160,236
Construction	102.91	32,872
Education	101.80	121,714
Furniture and Textiles	101.70	22,130
Real Estate	101.40	146,263
Agriculture, Fishing, Mining	100.47	32,526
Media, Art, Photography	97.68	42,528
Retail	97.36	99,395
Transportation	96.44	24,583
Legal and Economic Consulting	95.64	109,802
Hotels and Catering	91.10	19,395
Consumer Services	90.66	26,415
Weighted Average/Sum	106.70	1,365,794

Notes: Employment of Highly Qualified Workers covers all employees holding a degree from a university or a technical college, who are subject to social security contributions. This definition excludes self-employed and public servants. Average Wages of Highly Qualified Workers are defined as average daily gross wages in 2000.

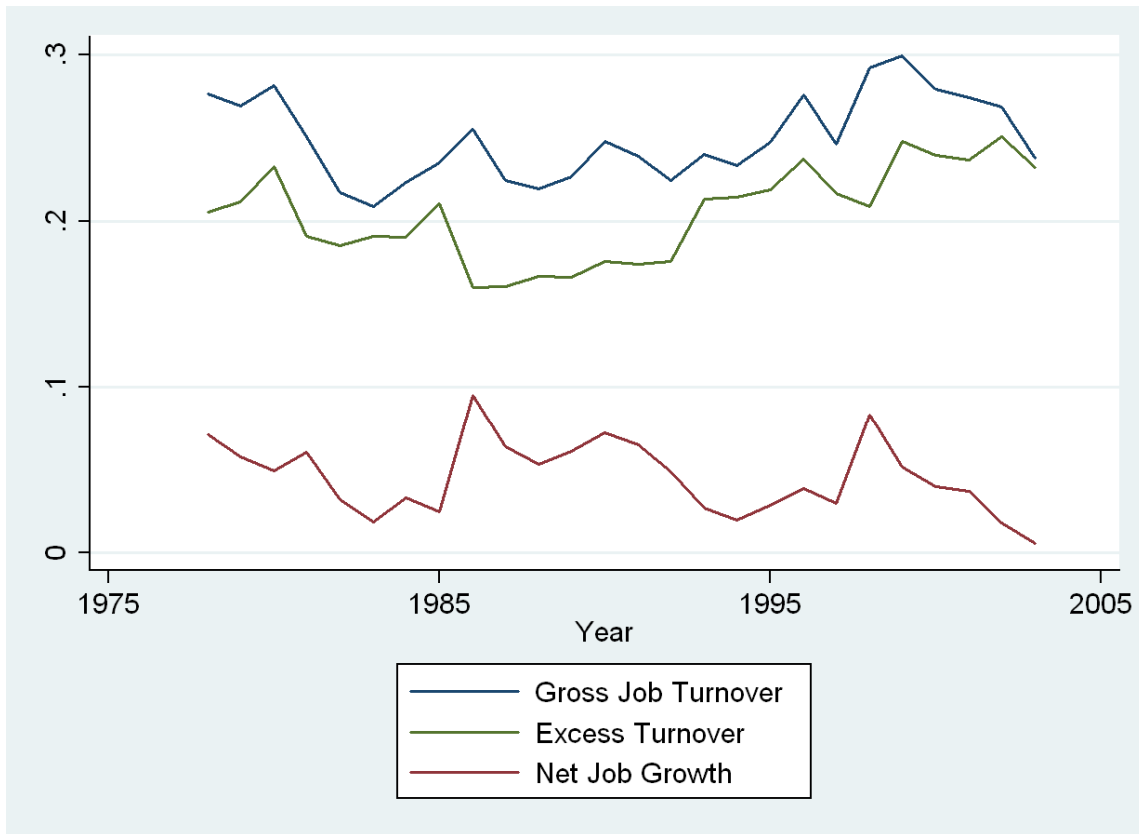
Map I: Regional Average Wages of Highly Qualified Workers, 2001



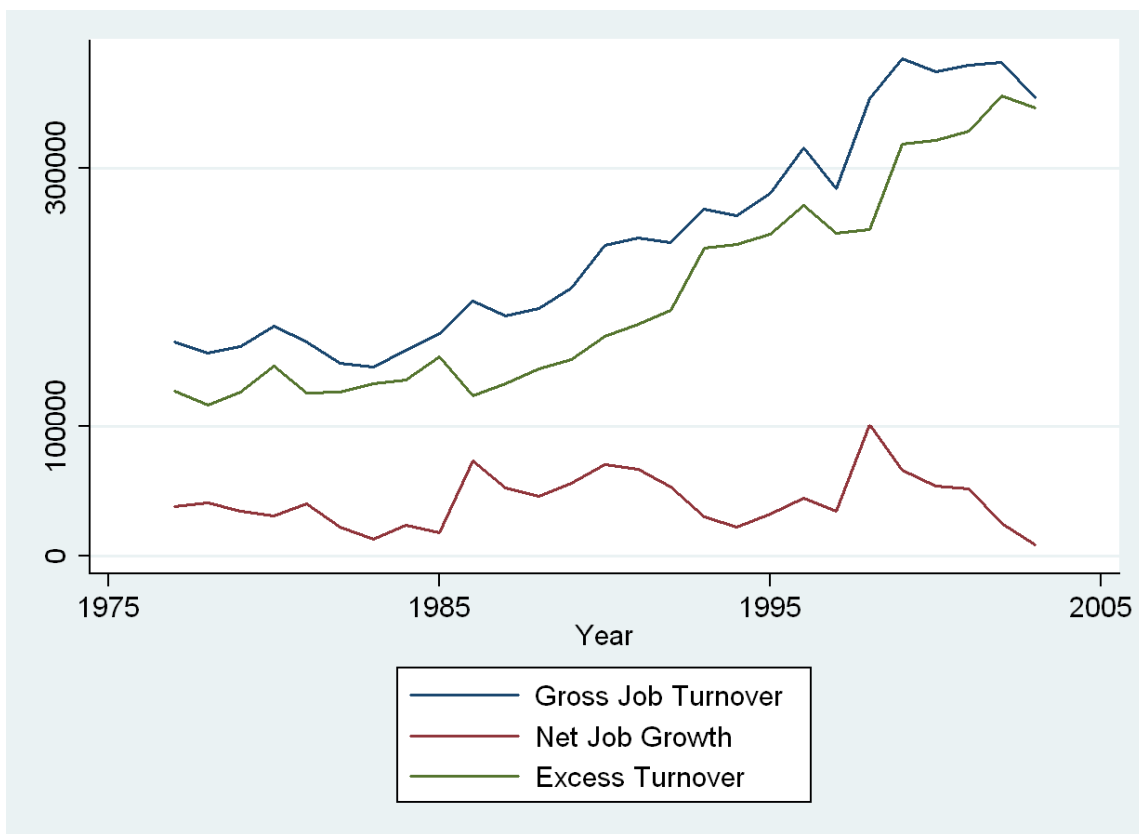
Map II: Regional Share of Highly Qualified Workers, 2001



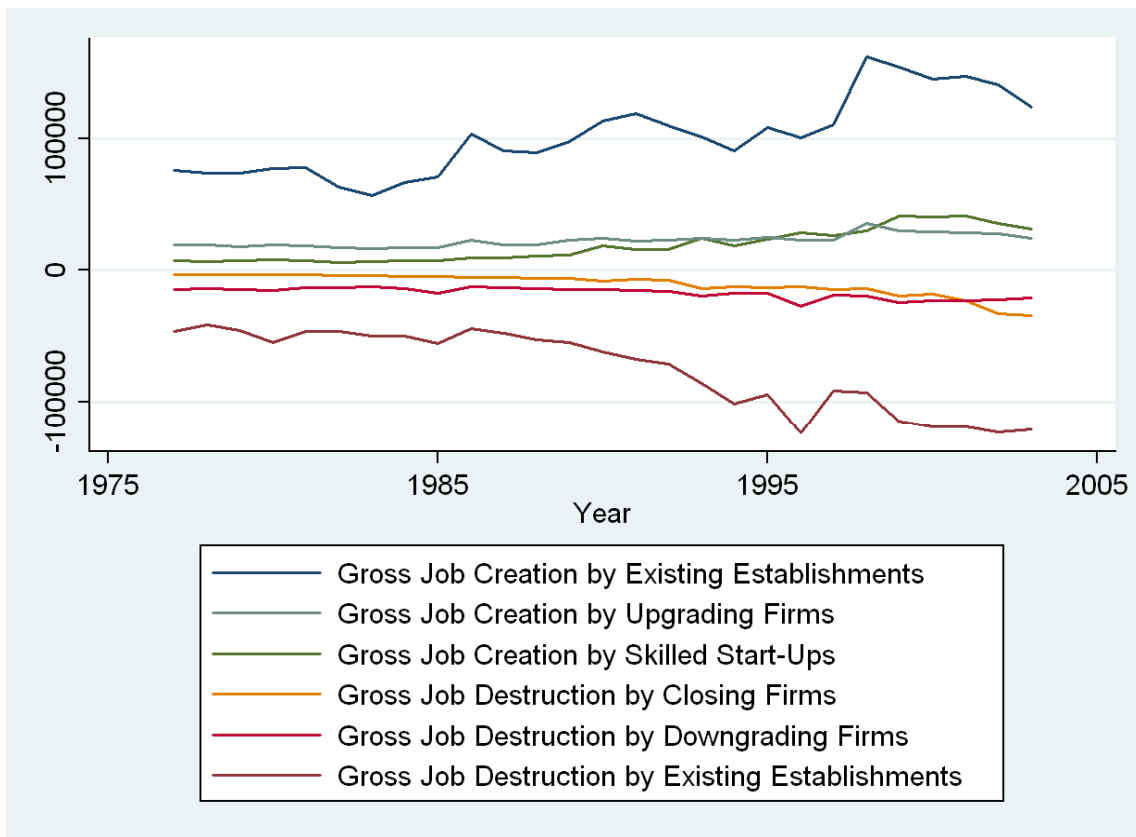
Graph I – Gross Turnover, Excess Turnover and Net Job Change: Rates



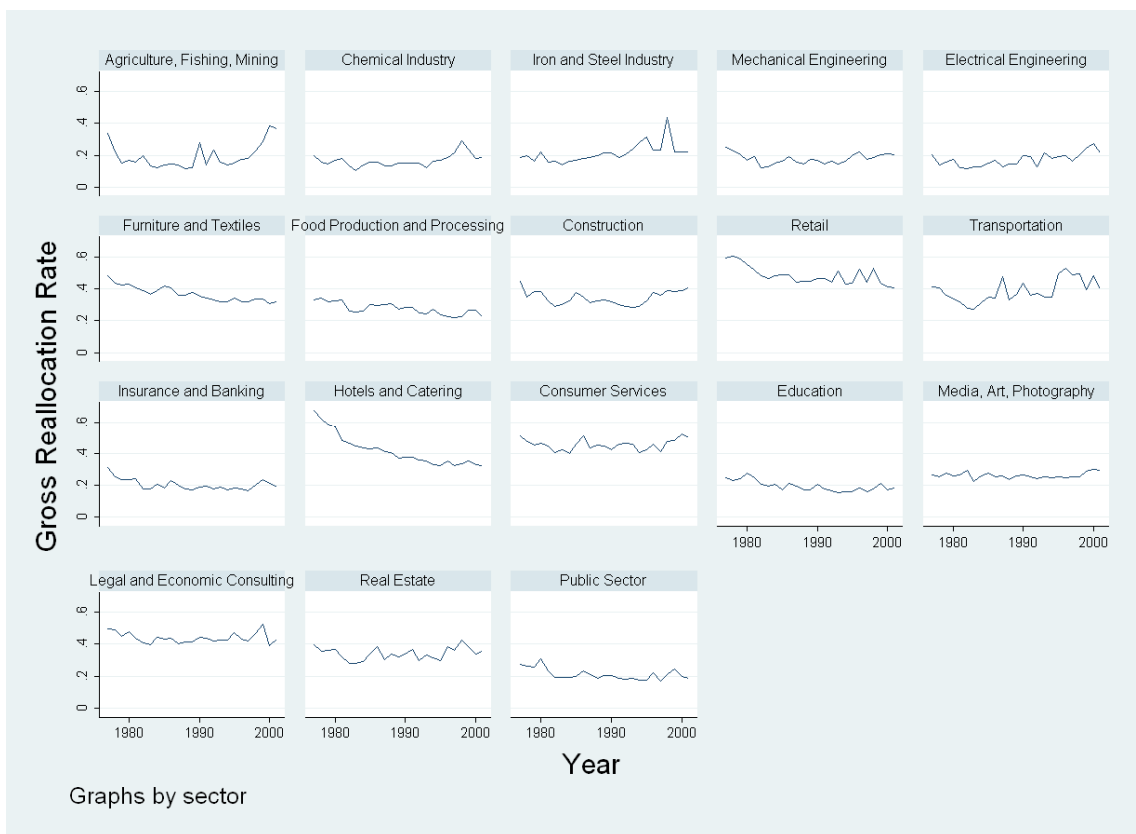
Graph II – Gross Turnover, Excess Turnover and Net Job Change: Flows



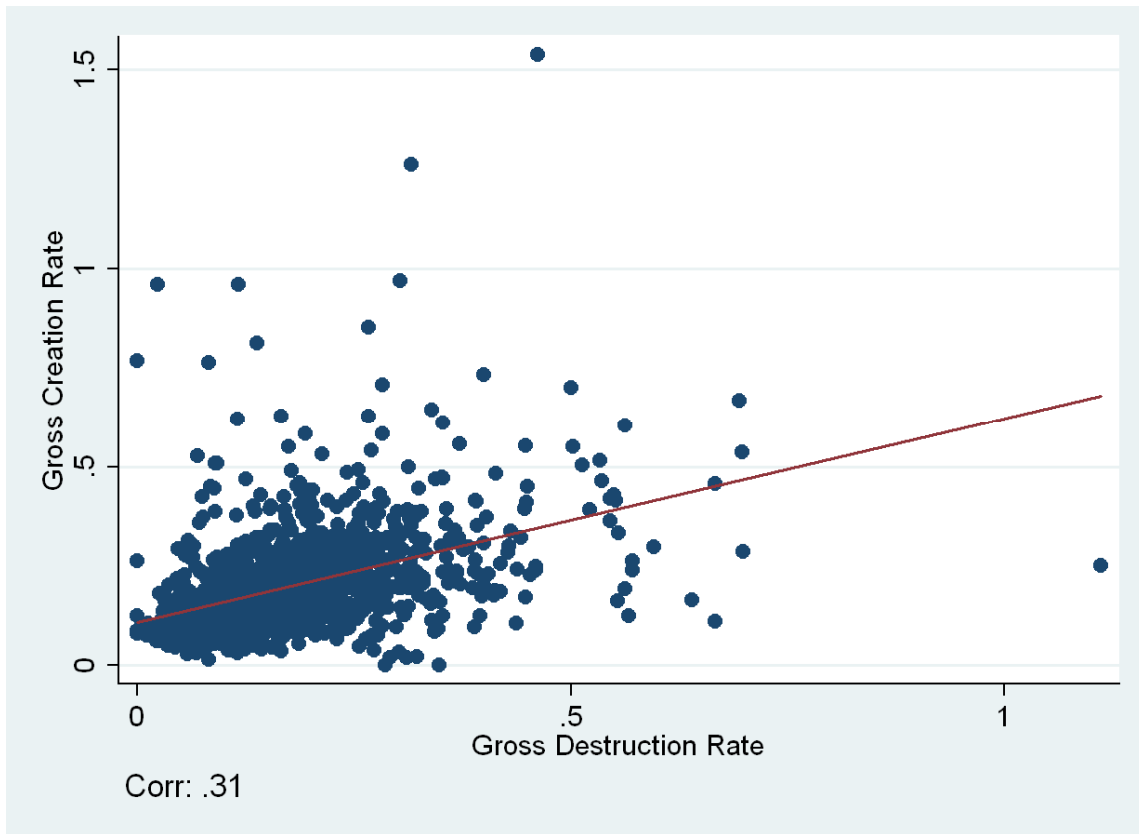
Graph III – Job Creation and Destruction by Firm Type: Flows



Graph IV – Sectoral Gross Reallocation Rates



Graph V – Annual Gross Creation and Destruction Rates, Region-Sectoral Level, 2002



Graph VI – Industrial Concentration by Sector

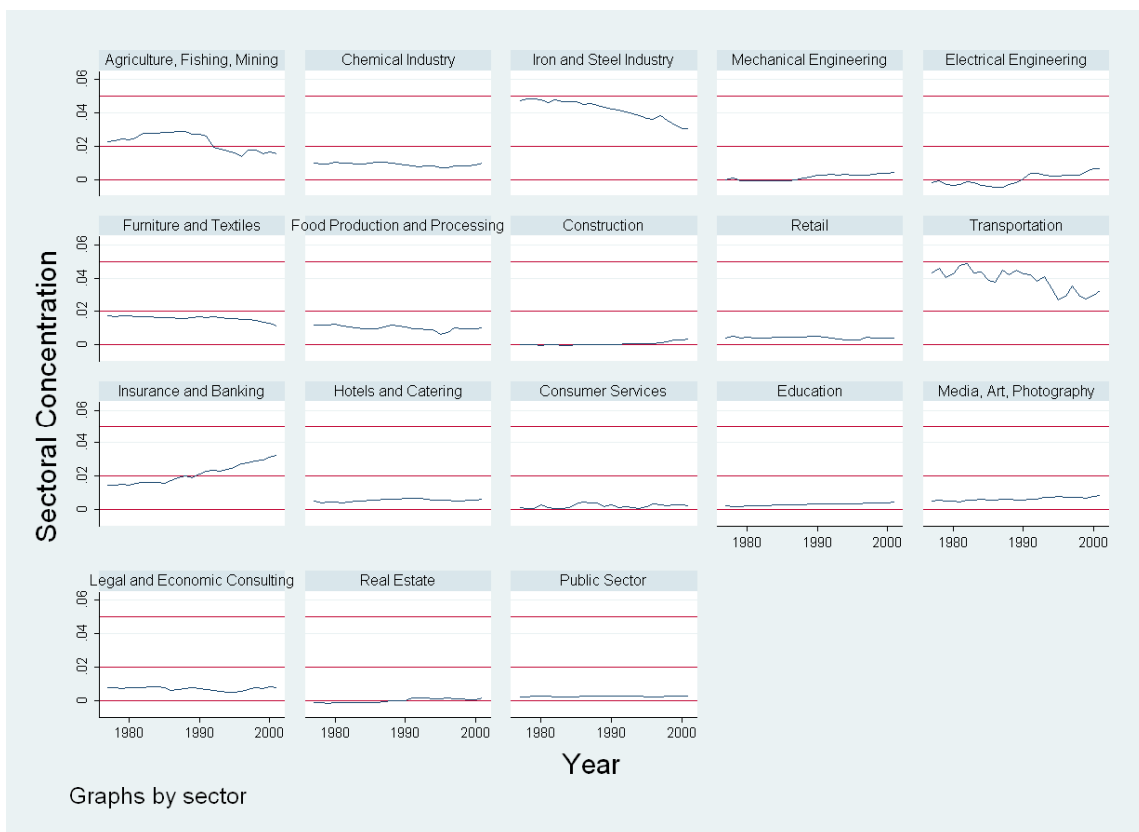


Table II – Skills and Industrial Change: Regional Industries (I)

	Dependent Variable:	ln(Mean Wage of Highly Qualified Workers per Region [per Sector] per Year)				
		(I)	(II)	(III)	(IV)	(V)
Change	Region-Sectoral Job Turnover Rate	-	-0.141 (.008)***	-0.188 (.014)***	-0.523 (.032)***	-
	Region-Sectoral Job Turnover Rate ²	-		-	0.256 (.019)***	-
	Regional Job Turnover Rate	-		-	-	-0.466 (.084)***
Skills	Region-Sectoral Share HQ	-1.17 (.066)***	-1.42 (.072)***	-1.36 (.074)***	-1.57 (.087)***	-
	Region-Sectoral Share HQ ²	1.93 (.135)***	2.09 (.135)***	2.05 (.136)***	2.31 (.150)***	-
	Regional Share HQ	0.139 (.468)	-	-0.015 (.527)	-0.432 (.535)***	-1.17 (.861)
	Regional Share HQ ²	-2.90 (1.37)**	-	-3.62 (1.43)**	-2.61 (1.45)*	-8.99 (2.28)***
Skills and Change	Region-Sectoral Share HQ*Region-Sectoral Job Turnover Rate	-	0.699 (.089)***	0.572 (.096)***	1.21 (.207)***	-
	(Region-Sectoral Share HQ*Region-Sectoral Job Turnover Rate) ²	-	-	-	-1.76 (.799)**	-
	Regional Share HQ*Region-Sectoral Job Turnover Rate	-	-	0.924 (.225)***	2.61 (.489)***	-
	(Regional Share HQ*Region-Sectoral Job Turnover Rate) ²	-	-	-	-11.3 (3.31)***	-
	Regional Share HQ*Regional Job Turnover Rate	-	-	-	-	4.27 (1.13)***
Controls	Average Firm Size	0.035 (.0004)***	0.035 (.0004)***	0.035 (.0004)***	0.035 (.0004)***	-0.016 (.018)
	Ln(No of HQ Workers per Region)	0.441 (.041)	0.541 (.033)***	0.408 (.043)***	0.395 (.043)***	0.709 (.068)***
	Ln(No of HQ Workers per Region) ²	-0.025 (.003)***	-0.031 (.002)***	0.037 (.003)***	-0.022 (.003)***	-0.015 (.005)***
	Ln(No of HQ Workers per Region-Sector)	0.056 (.003)***	0.038 (.003)***	-0.023 (.003)***	0.039 (.003)***	-
	Ln(No of HQ Workers per Region-Sector) ²	0.002 (.0003)***	0.003 (.0003)***	0.003 (.0003)***	0.002 (.0003)***	-
	Regional Unemployment Rate	-	0.0002 (.001)	-0.0008 (.001)	-0.0008 (.001)	-0.008 (.002)***
	Regional Unemployment Rate*Job Turnover Rate	-	0.003 (.015)	0.019 (.018)	0.022 (.017)	0.143 (.027)***
	Year Dummies	Yes	Yes	Yes	Yes	Yes
	Sector Dummies	Yes	Yes	Yes	Yes	No
	Region Dummies	Yes	Yes	Yes	Yes	Yes
Adj. R ²	.70	.71	.71	.71	.94	
No. of Observations	33,382	31,950	31,950	31,950	1,776	

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; all columns refer to sectors within regions as their unit of observation, except Column III, where the labor market region is the unit of observation; consistently, Average Firm Size is measured on region-sectoral level, except in Column III, where it refers to regional averages.

Table III – Skills and Industrial Change: Regional Industries (II)

Dependent Variable:	ln(Mean Wage of Highly Qualified Workers per Region per Sector per Year)				
	(I)	(II)	(III)	(IV)	(V)
Change Intensity	-.216 (.019)***	-.121 (.024)***	-.305 (.033)***	-.117 (.024)***	-.026 (.044)
Region-Sectoral Share HQ *Change Intensity	.680 (.127)***	.375 (.163)**	.702 (.221)***	.599 (.151)***	.042 (.326)
Regional Share HQ *Change Intensity	1.07 (.322)***	.813 (.395)**	1.34 (.529)***	.915 (.407)**	.822 (.803)
Indicator for Intensity of Industrial Change	Job Creation Rate	Job Destruction Rate	Excess Churning Rate	Positive Job Growth Rate	Negative Job Growth Rate
Adj. R ²	.71	.70	.70	.71	.66
No. of Observations	31,950	33,282	33,282	23,842	9,372

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; control variables throughout all regressions are Regional Share of HQ, Region-Sectoral Share of HQ, Region Size, Region-Sectoral Size, as well as their respective squares, and Average Region-Sectoral Firm Size, Unemployment, and an interaction term containing the product of Unemployment and the Labor Market Shock; all regressions contain full sets of region, sector, and time dummies.

Table IV – Adverse Employment Adjustment and Human Capital Externalities: Firms

		Dependent Variable:	ln(Median Wage of Highly Qualified Workers per Firm per Year)				
			(I)	(II)	(III)	(IV)	(V)
Adverse Change	Sector-Congruent Firm Adjustment *	.093 (.007)***	.091 (.007)***	-.007 (.032)	.099 (.007)***	.057 (.019)***	
	Average Adverse Growth						
	Sector-Adverse Firm Adjustment *	.023 (.005)***	.020 (.006)***	.012 (.012)	.004 (.011)	.020 (.008)***	
Industrial Change	Firm	Sector-Congruent Firm Adjustment	-.041 (.001)***	-.040 (.001)***	-.022 (.005)***	-.042 (.001)***	-.031 (.003)***
		Sector-Adverse Firm Adjustment	-.026 (.001)***	-.028 (.001)***	-.017 (.001)***	-.015 (.001)***	-.032 (.001)***
	Reg-Sect	Sector Growth	-.002 (.009)	-.009 (.003)***	-.014 (.004)***	-.009 (.003)***	-.009 (.007)
		Average Adverse Adjustment	-.129 (.015)***	-.058 (.006)***	-.042 (.006)***	-.076 (.007)***	-.031 (.009)***
Controls	Share of HQ Employees	-.317 (.011)***	-.315 (.012)***	-.325 (.015)***	-.319 (.012)***	-.272 (.025)***	
	Share of HQ Employees ²	.402 (.024)***	.399 (.027)***	.403 (.034)***	.406 (.028)***	.343 (.059)***	
	Share of HQ Employees ³	-.227 (.016)***	-.224 (.017)***	-.225 (.021)***	-.229 (.018)***	-.198 (.038)***	
	Number of Employees	17.7 (.279)***	16.5 (.378)***	19.0 (.423)***	17.2 (.338)***	18.2 (.574)***	
	Number of Employees ²	-49.2 (2.08)***	-45.0 (2.73)***	58.2 (3.43)***	-46.6 (2.47)***	-53.5 (4.44)***	
	Number of Employees ³	.003 (.0003)***	.004 (.0004)***	.006 (.0006)***	.004 (.0003)***	.006 (.0007)***	
	Year Dummies	Yes	Yes	Yes	Yes	Yes	
	Sector Dummies	Yes	Yes	Yes	Yes	Yes	
Region Dummies	Yes	Yes	Yes	Yes	Yes		
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes		
Sample	All Firms	Growing Firms	Shrinking Firms	Growing Sectors	Contracting Sectors		
Adj. R ²	.10	.09	.07	.09	.07		
No. of Observations	3,272,125	2,833,135	2,146,351	2,526,205	784,889		

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 Number of Employees are multiplied by 10⁵, coefficients and standard errors for quadratic and cubic terms thereof are multiplied by 10¹⁰.

Table V – The Dynamics of Industry Change and the Geography of Industrial Location

Dependent Variable:	Relative Region-Sectoral Employment	Ln(Absolute Region-Sectoral Employment)	Ellison-Glaeser Index of Industrial Concentration
	(I)	(II)	(III)
Average Sector-Congruent Adjustment, Sectoral Level	-	-	-.025 (.009)***
Average Sector-Adverse Adjustment, Sectoral Level	-	-	.009 (.02)
Average Sector-Congruent Adjustment, Region-Sectoral Level	-.012 (.008)	-.006 (.008)	-
Average Sector-Adverse Adjustment, Region-Sectoral Level	.023 (.009)***	.029 (.009)***	-
Sectoral Employment	-	-	.113 (.011)***
Year Dummies	Yes	Yes	Yes
Sector Dummies	Yes	Yes	Yes
Region Dummies	Yes	Yes	No
Adj. R ²	.14	.81	.95
No. of Observations	31,950	31,950	450

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 sectoral employment are multiplied by 10⁶.

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