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Human Capital Externalities in Western Germany

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Abstract

The paper sheds light on the impact of local human capital endowments on individual wages in Western Germany. Using panel data it shows that regional wage differentials are partly attributable to localized human capital externalities arising from the regional share of highly qualified workers. Employing the regional number of public schools and of students as instrumental variables, the paper shows that human capital externalities are underestimated in ordinary panel regressions for highly qualified workers due to supply shifts of workers of different skills. An analysis by sector reveals that human capital externalities are more pronounced in manufacturing than in the service sector. We find indication that highly qualified workers benefit from intra-industry knowledge spillovers, while non-highly qualified workers profit from pecuniary externalities between industries. Our findings are stable among a variety of indicators of regional human capital and robust to the inclusion of other sources of increasing returns, as well as wage curve, price level, and amenity effects.

Keywords: Human Capital Externalities, Agglomeration, Urban Wage Premium
JEL Categories: D62, D83, J24, J31, O15

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I. Introduction – Human Capital Externalities and Regional Wages

> *"It is an odd fact that the economic basis for major elements of public policy and expenditure depends importantly on the size of one of the least well measured of all economic phenomena: human capital externalities."*
>
> Jim B. Davies (2002: 1)

Despite the distribution of wages and human capital being uneven between countries and within countries alike, regional human capital endowments have rather late attracted attention as determinants of regional development. The link between human capital agglomeration and regional prosperity was first pointed out by early development economists like Myrdal (1954), Kuznets (1962), Hirschman (1958), and Kaldor (1970), who emphasized that the spatial agglomeration of human capital creates benefits over and above the private returns reaped by individuals. In contemporary economic theory these social benefits are usually regarded as resulting from either market or non-market human capital externalities (Moretti 2004a). Arguments based on technological market externalities have gained prominence through Arrow (1962), Romer (1986), and Lucas (1988), who argue that human capital externalities arising from uncompensated learning processes between individuals are an important source of economic growth. Acemoglu (1996) shows that pecuniary market externalities from human capital arise if firms choose their investment in physical capital in anticipation of the average human capital of their future workers. Non-market externalities from human capital frequently mentioned in the literature include reductions in crime rates, better informed voting decisions, or improved health-related behavior (Davies 2002).

These theoretical insights as well as Rauch's (1993) empirical finding that geographic concentration of human capital significantly raises productivity and wages have sparked a controversial debate on the extent to which higher urban wages and productivity are the result of positive externalities from the agglomeration of human capital. Although empirical studies show that a doubling of employment density increases wages and productivity by about six percent in the US (Ciccone/Hall 1996), five percent in European countries (Ciccone 2002), and four percent in the UK (Anastassova 2006) it has remained contested to which extent this premium can be attributed to human capital externalities. Glaeser/Maré (2001) argue that while a large part of the urban wage premium is due to spatial sorting of workers with respect to observable and unobservable characteristics, human capital externalities increase urban wages by about twelve percent. In a similar vein Combes/Duranton/Gobillon (2008) assign a wage increase of about three percent to human capital externalities arising in French cities. In general, uncertainty on the

precise magnitude of human capital externalities is rooted in substantial methodological problems of identification. Ciccone/Peri (2006) emphasize that omitted regional variables constitute a serious threat to the correct identification of human capital externalities and that neglecting shifts of supply and demand of skills can lead to heavily biased estimates. Acemoglu/Angrist (2000) employ an instrumental variable strategy and show that social returns from education range below one percent and thus are substantially below earlier estimates. Notwithstanding these challenges sound theoretical reasons as well as tentative empirical evidence suggest that human capital externalities are an important determinant of productivity and wages and therefore constitute an important piece in the puzzle of uneven regional development.

Given the ardent debate on social returns to education in the US labor market it comes as a surprise that only one study (Suedekum 2008) addresses the issue of human capital externalities in the German labor market. This general retention is startling since German regions are shaped by substantial differences in economic performance with areas of agglomeration being particularly advantaged with respect to human capital, wages, and productivity. Regional wage differentials in Germany are investigated by Lehmer/Moeller (2009), who identify a raw urban wage premium of about fifteen percent, and by Moeller/Haas (2003), who find a doubling of employment density to raise individual wages by about 2.5 percent with these benefits increasing with individual level of skills. Suedekum (2008) is the only study that directly addresses the issue of human capital externalities by analyzing the impact of regional human capital on employment growth. His finding that regional human capital endowments positively influence employment growth of low-skilled workers does, however, support theories of neoclassical complementarities between skilled and unskilled workers rather than explanations based on human capital externalities.

Summing up, it turns out that the fundamental question of the extent to which human capital externalities are a driving force behind the urban wage premium in Germany has hitherto been left unaddressed. The present paper fills this gap and investigates whether regional wage differentials in Germany can at least partly be attributed to human capital externalities. We employ an instrumental variable approach as a central identification strategy in order to distinguish human capital externalities from other sources of regional wage disparities. Our main concern is that regional shifts in the supply of skills and other unobservable variables might bias our estimates. We therefore employ the regional number of public schools and of students attending them as instruments for the regional share of human capital. The instruments are based on the idea that future urban labor supply is a valid

instrument for today's regional share of highly qualified workers. The intuition behind our instruments is that the regional number of public schools and the number of students attending them are both closely related to regional human capital endowments since students from peripheral areas more than proportionally attend public schools in urban areas, change to the respective city's university after graduating from school, and from there enter the city's labor market. Both instruments are exogenous in Mincerian wage regressions since individual wages can reasonably be assumed not to be influenced by the number of schools or the number of students. A broad band of statistical tests corroborate our theoretical considerations on instrumental relevance and exogeneity.

Based on these instruments our analysis shows that in line with Moretti's (2004b) findings for the US human capital externalities have a substantial positive impact on individual wages in Germany and that this effect first and foremost works through the impact of the regional share of highly qualified workers. This effect is not only stable among a broad range of indicators for regional human capital, but also robust to the inclusion of other sources of increasing returns, as well as to wage curve, price level and amenity effects, and, finally, to neoclassical explanations of supply and demand. Comparing our results from instrumental variable regressions to those from regressions without instruments we find that in ordinary least squares regressions the impact of human capital externalities is heavily underestimated for wages of highly qualified and non-highly qualified workers alike, a finding we attribute to shifts in the supply of highly qualified workers which reduce wages for both types of workers through partly shared labor markets. In addition to being the first study on wage determining effects of human capital externalities in Germany, our study adds to the literature by investigating the relative importance of technological and pecuniary human capital externalities. Estimating wage regressions separately for each of the sixteen industries in our sample we find strong evidence that while highly qualified workers mainly benefit from intra-industry knowledge spillovers, wages of non-highly qualified workers are affected predominantly through pecuniary human capital externalities arising between industries. Our instrumental variable approach furthermore shows that human capital externalities are on average about fifty percent smaller in the service sector than in manufacturing which we interpret as evidence for the relative importance of pecuniary externalities in manufacturing.

The finding of substantial positive human capital externalities impacting on wages of highly skilled workers is not only of academic interest. It is also of prime importance for an adequate design of regional policy since it pinpoints a core conflict of objectives. A regional policy committed to the objective of efficiency is certainly well advised to foster the spatial agglomeration of human capital. This is frequently done

today through considerable public investments into an infrastructure for the exchange of knowledge and information with knowledge clusters, science parks, and innovation centers being prime examples. This type of efficiency-oriented regional policy, however, stands in sharp contrast to Article 91 of the Constitution, which obliges the German government to promote an equal development of all regions Germany and to actively support the catching-up process of regions lagging behind.

Section II sets the stage for the empirical investigation by deriving an econometric model for the identification of the impact of human capital externalities on wages; Section III summarizes the data and provides descriptive evidence on the spatial distribution of wages and human capital among German regions before presenting the results from the empirical analysis in depth; Section IV concludes.

II. Human Capital Externalities: Theory and Identification

In this section we develop a simple model from which we derive testable hypotheses on how the share of skilled workers impacts on the wages of skilled and unskilled workers. We then contrast the idea of knowledge spillovers to other potential sources of regional wage differentials put forth in the literature, i.e. to labor pooling and input-output linkages as alternative sources of increasing returns, and to wage curve, price level, and amenity effects. From this we derive an empirical identification strategy which we think is capable of differentiating between these rivaling explanations.

II.1. Human Capital Externalities: Theoretical Framework

The empirical investigation in this paper relies on a simple model, which is a modified and adapted version of Moretti (2004a). It is important to note that this model is compatible with technological externalities arising from learning processes, as well as with pecuniary externalities arising from firms' expectations on future human capital. This all-encompassing model is in line with our objective to shed light on the overall size of human capital externalities in Western Germany. Like Acemoglu/Angrist, who with respect to the American labor market do "not to attempt to distinguish between these mechanisms, since they have similar implications" (1999: 6), we do not aim to quantify the relative influence of both types of externalities, an aspiration we regard as not very promising, and restrain ourselves to pointing out evidence for technological or pecuniary externalities wherever our results indicate the prevalence of either one. The model is based on a production function that uses two types of

labor as input and exhibits increasing returns to human capital. More specifically, output in region j is assumed to be produced under Cobb-Douglas technology using skilled labor (N_{1j}) and unskilled labor (N_{2j}) as inputs:

$$Y_j = \left(\theta_{1j} N_{1j}\right)^{\alpha_1} (\theta_{2j} N_{2j})^{1-\alpha_1} \tag{1}$$

It is further assumed that productivity of skilled and unskilled labor θ_{ij} is a function of individual productivity enhancing skills ϕ_{ij} with $\phi_{1j} > \phi_{2j}$ and of increasing returns arising from the ratio of skilled labor to total workforce in city j.

$$\log\left(\theta_{ij}\right) = \phi_{ij} + \gamma\left(\frac{N_{1j}}{N_{1j}+N_{2j}}\right) \tag{2}$$

Obviously, with $\gamma = 0$ individual productivity depends exclusively on individual human capital with skilled workers by definition being endowed with a higher amount of human capital. If wages equal the marginal product of labor it is straightforward to see that with $s_j = (N_{1j}/N_{1j}+N_{2j})$ the logarithms of wages for skilled workers w_{1j} and for unskilled workers w_{2j} are:

$$\log\left(w_{1j}\right) = \log(\alpha_1) + \alpha_1 \log\left(\theta_{1j}\right) + (\alpha_1 - 1)\log\left(s_j\right) + (1-\alpha_1)\log\left(\theta_{2j}\right) + (1-\alpha_1)\log\left(1-s_j\right) \tag{3}$$

$$\log\left(w_{2j}\right) = \log(1-\alpha_1) + \alpha_1 \log\left(\theta_{1j}\right) + \alpha_1 \log\left(s_j\right) + (1-\alpha_1)\log\left(\theta_{2j}\right) - \alpha_1 \log\left(1-s_j\right) \tag{4}$$

To understand what happens to wages when the regional share of skilled workers increases we take first derivatives $dlog(w_{1j})/ds$ and $dlog(w_{2j})/ds$, which yields:

$$\frac{dlog(w_{1j})}{ds_j} = \gamma + \frac{\alpha_1 - 1}{s_j(1-s_j)} = \gamma + \frac{\alpha_1 - 1}{s_j - s_j^2} \tag{5}$$

$$\frac{dlog(w_{2j})}{ds_j} = \gamma + \frac{\alpha_1}{s_j(1-s_j)} = \gamma + \frac{\alpha_1}{s_j - s_j^2} \tag{6}$$

An increase in the share of skilled workers impacts on wages of skilled and unskilled workers in two ways, i.e. through human capital externalities γ, and through neoclassical supply effects arising from imperfect substitution of skilled and unskilled workers. Human capital externalities γ have a positive effect of the same magnitude on wages of all workers. Supply effects, in contrast, work in opposite directions for both types of workers; an increase in the share of skilled workers increases wages for unskilled workers and depresses those of skilled workers. Adding up externality and supply effects reveals that an increase in the share of skilled workers has a non-linear

influence on both the wages of skilled and unskilled workers with this effect being unambiguously positive for unskilled workers and undetermined for wages of skilled workers. Unskilled workers benefit from an increase in the share of skilled workers through human capital externalities and through an increase of their relative scarcity. For skilled workers the effect of a positive supply shift depends on whether human capital externalities γ can overcompensate the negative neoclassical supply effect.

These findings provide the theoretical underpinning of our empirical analysis. Based on this model we formulate three hypotheses. We expect a) the regional density of human capital to have an effect on the wages of skilled and unskilled workers through the working of human capital externalities, b) the effect of human capital externalities to be of the same magnitude for skilled and unskilled workers, and c) supply shifts of skills to have a negative impact on the wages of skilled workers and a positive impact on those of unskilled workers. The model emphasizes the necessity to find an identification strategy which is able to disentangle the effects of human capital spillovers from those of supply shifts of skills. If not controlled for shifts in skills, human capital externalities are prone to be underestimated for skilled workers and overestimated for unskilled workers. The solution opted for here is to estimate the impact of regional capital on wages separately for skilled and unskilled workers employing an instrumental variable approach. The challenge is to find an instrumental variable which is related to the share of skilled individuals but is constant enough over time so as to not be related to shifts of skills (Angrist/Krueger 2001). We decide to use the local number of public schools and students attending them as instruments for the regional share of human capital. Before elaborating on the validity of these instruments we briefly outline alternative explanations for regional wage differentials which have been discussed in the literature and which partly shape our identification strategy.

II.2. Alternative Explanations for Regional Wage Differentials

Alternative theories on the development and the existence of regional wage differentials comprise increasing returns arising from economic density, as well as wage curve, amenity, and price level effects.

Arguments focusing on localized increasing returns to scale go back to Marshall (1890), who identifies labor market interactions, input-output linkages, and knowledge spillovers, the latter one being synonymous to technological externalities from human capital, as core mechanisms through which spatially bounded externalities come into existence (see Rosenthal/Strange 2004 for an overview).

Closely related to Marshall's early categorization, Duranton and Puga (2004) distinguish between matching, sharing, and learning mechanisms. Matching approaches are based on the idea that a large number of employers and employees in a regional labor market increase the chances of a high-quality match between workers and firms which in turn increases labor productivity. In sharing models spatial proximity to producers and to consumers allows firms to economize on transaction costs, which in turn leads to lower prices, increased demand, higher output, and higher wages. Both matching and sharing externalities are broadly regarded as arising from the mass of economic activity in general, rather than from the concentration of human capital. Since, however, the density of economic processes is prone to be correlated with the regional share of human capital we control for the regional extent of agglomeration in our empirical analysis.

Blanchflower/Oswald (1990) show empirically that with a doubling of unemployment average wages decrease by approximately ten percent, a finding since then known as the 'wage curve'. Notwithstanding the lack of an undisputed theoretical underpinning, this relation has been shown to hold to a different extent for practically all industrialized countries. With respect to Germany, Blien (2003) shows that a doubling of unemployment reduces wages by six percent. Since Suedekum (2003) finds that unemployment tends to be lower in cities than in rural areas we are suspicious that unemployment might be correlated with regional human capital endowments and account for it in our subsequent analysis.

Roback (1982) was the first to show in a general equilibrium framework that regional amenities have an impact on wages and that the direction of this impact depends on whether these amenities are productive or not. Productive amenities by definition increase productivity and wages while non-productive amenities, in contrast, have a depressing effect on regional wages because workers having a preference for the respective amenity accept lower wages for being close to the amenity. Accordingly, Beeson (1991) empirically demonstrates that about forty percent of regional wage differentials in the US can be attributed to different amenity endowments. Whether or not land prices are a wage determining factor depends on the assumption of firm mobility. If firms display a lower mobility than workers they will compensate workers for higher land prices, since only by paying higher wages they can prevent workers from moving to places characterized by lower costs of living (Moretti 2004a). Firms are willing to compensate their workers for congestion as long as the costs of compensation are lower than the costs of relocation (Kim 2003). Yankow (2006) empirically shows that regional price levels have an ambiguous effect on wages. Brueckner/Thisse/Zenou (1999) demonstrate that the concentration of human capital increases with local amenities while Alonso-Villar (2002) shows that price levels are

closely linked to the share of skilled workers. We therefore decide to control for regional amenities and price levels in our analysis.

II.3. Identifying Human Capital Externalities

It is certainly true that "the principal challenge in any effort to estimate the effects of education on wages is identification" (Acemoglu/Angrist 2000: 2). The main obstacle to an exact identification of the size of externalities is the existence of unobservable wage determining factors on the individual, as well as on the regional level. In order to shed light on the impact of regional human capital externalities on wages we employ Mincerian individual wage equations augmented by regional wage determining factors. Individual wages are on the one hand determined by individual productivity relevant factors, all of which are familiar from a voluminous literature starting with the seminal works of Mincer (1974) and Becker (1975). In addition to individual factors we introduce aggregate variables to account for competing explanations of the urban wage premium outlined above. In its most general form the equation to be estimated reads

$$\log(w_{irt}) = X_{irt}\beta_k + \eta_1 D^{HQ} \times H_{rt} + \eta_2 D^{NHQ} \times H_{rt} + Z_{rt}\delta_j + \varphi U_{rt} + \tau P_{rt} + A_{rt}\lambda_m + d_{ir} + d_t + d_r + \varepsilon_{irt} \quad (7)$$

with w_{irt} denoting the wage of individual i in region r at time t and X_{irt} being individual productivity relevant criteria including age, sex, education, experience, and tenure. In order to examine our second hypothesis, i.e. whether regional human capital exerts the same effect on different types of workers, we interact the regional share of human capital H_{rt} with dummy variables according to whether individual i is highly qualified (D^{HQ}), or non-highly qualified (D^{NHQ}). Z_{rt} is a measure for regional agglomeration which controls for localized increasing returns arising from matching or sharing mechanisms outlined above. U_{rt}, P_{rt} and A_{rt} represent the regional unemployment rate, regional price levels, and the amount of regional amenities respectively. In order to control for unobservable effects we include d_{ir}, d_t and d_r as individual, time, and regional fixed effects. ε_{irt} is an error term with the usual properties.

Our primary goal is the correct identification of η_1 and η_2 in equation (7), which represent social returns to human capital. Our core identifying assumption is that no variable exists on a regional level which is correlated with the regional share of human capital, systematically influences individual wages, and is not included in the equation either directly or via an adequate proxy variable. The panel structure of the dataset enables us to control for unobserved heterogeneity at the individual as well as

at the regional level by including fixed effects. Fixed effects regression are, however, not able to account for supply and demand shifts of skilled and unskilled labor since these shifts are constant neither over time, nor within one entity.

In order to correctly identify the impact of human capital externalities on wages we use an instrumental variable approach (see Griliches/Hausman 1986). The instrumental variables used are inspired by Moretti (2004b), who uses the lagged city demographic structure and the number of land-grant colleges as instruments for regional human capital. We analogously resort to the idea that the future supply of highly-skilled workers is a valid instrument for today's regional human capital endowment. Based on this notion we employ the number of public schools in a region and the number of students attending them as instruments for the share of highly qualified workers. The intuition behind these instruments is that the number of public schools which qualify students for attending university, i.e. first and foremost Gymnasia (grammar schools), and the number of students attending them increases more than proportionally with regional density. This stems from the fact that not every city is able to maintain a Gymnasium, which means that children commute to larger cities in order to attend this type of schools. A substantial part of the students attending Gymnasia change to the university in the respective city after having finished school and later in life often start their first job there. The fact that highly qualified workers often attend higher education institutions in the city they went to public school in can partly be explained by the high degree of decentralization of universities and technical colleges in Germany. Since 139 of the 326 counties in Western Germany contain a university or a technical college it is easy for young people to stay close to their friends and family during school and university education and, later on, when starting their first job to stay in the city they already went to school in. Since the plausibility of this home-bias argument is mirrored in numerous contributions on the notoriously low mobility rates of German workers and students (see e.g. Haas 2002 and Hillmert 2004) we believe that the number of public schools and the students attending them are relevant instruments for the regional share of human capital. As for instrument exogeneity, it is hard to see why individual productivity should be influenced by the aggregate number of public schools or students. Various statistical tests in Section III confirm our intuition on instrumental relevance and exogeneity.

Some comments are in order with respect to the variables used in the analysis below. Our variable of interest, i.e. regional human capital endowment, is measured in four different ways. The preferred indicator for regional human capital is the share of highly qualified workers among the workforce within a region. Highly qualified workers are defined as those who hold a degree from a university or a technical

college.[1] The assumption underlying this variable is that productivity enhancing knowledge is to a large extent embodied in highly qualified people and from there radiates to the rest of the workforce via knowledge spillovers. The downside of using the share of highly qualified workers as an indicator of regional human capital is that it ignores the distribution of skill among the non-highly qualified. Since it is quite plausible that human capital externalities are not unique to the regional share of highly qualified workers but to the average level of education of the regional workforce, we introduce average education as an alternative measure of regional human capital. We construct this variable by assigning years of education to each type of formal degree and from these calculate average years of education in each region.[2] Finally, in order to investigate whether human capital externalities are rooted in the concentration of skills of a certain type we introduce the regional kurtosis of education and the Hirschman-Herfindahl index as measures for the intraregional distribution of human capital.

We use the absolute number of hotel beds per region as a proxy for a county's amenity endowment. Using hotel beds as a proxy for amenities addresses the problem that the majority of productive and unproductive amenities are not measurable and sometimes not even definable. The supply of hotel beds in a region indicates that it is attractive for people to travel into that region, be it out of leisure or business motives. The number of hotel beds is thus closely related to the idea of amenities, since their number expresses how attractive a place is for consumers or producers. Of course the use of one single variable impedes the disentangling of the respective impact of productive or unproductive amenities and the sign of that variable is therefore ambiguous, which is however of no relevance here.[3]

Congestion is proxied by the prices per square meter of sold land.[4] We are not able to control for overall regional consumer prices since no such index exists on a county level. Land prices are an adequate proxy, though, since congestion unfolds price effects to a large extent through land prices. Secondly, land prices are the basis for the calculation of rents, which constitutes the most important item of average

[1]Technical colleges ('*Fachhochschulen*') are supposed to be more practically oriented than universities and entry requirements are slightly below those for universities.

[2] Possible values are 'no formal education' (9 years), 'degree from Volks-/Haupt-/Realschule and subsequent vocational training' (13 years), 'Gymnasium without vocational training' (13 years), 'Gymnasium with vocational training' (16 years), 'degree from a technical college' (18 years), 'and university degree' (20 years).

[3] We have refrained from weighting the number of hotel beds according to regional population since a weighting approach is subject to the assumption that unproductive amenities have a greater weight. This arises from the fact most natural amenities are located in sparsely populated places. Weighting hotel beds according to population would more than proportionally increase their weight. In addition, using the number of hotels per region instead of the number of hotel beds per region does not make much difference, since they show a correlation of .922.

[4] We are using prices for sold land of all types, rather than prices for building land only since the data quality is much better; both types of land prices display a correlation of .967.

household expenditure. In accordance with DuMond/Hirsch/MacPherson (1999) we use land prices as a regressor on the right hand side rather than employing it to deflate wages, because the latter is subject to the unrealistic assumption that consumers do not adjust their buying or renting behaviour in the face of high prices or rents.

Finally, as pointed out by Moulton (1990), standard errors of regional variables are prone to be inflated, since regional variables are not assigned randomly to individuals. Therefore, all regressions are cluster corrected using Newey-West standard errors with the share of highly qualified workers being the cluster identifying variable (Newey/West 1987; Rogers 1993). Since the Newey-West procedure is much stricter than required by Moulton we do not run into danger of overestimating the impact of regional human capital on wages (Hoxby 2000).

III. Human Capital Externalities and Regional Wages

III.1. The Data

The data needed for the analysis is taken from four sources. Individual data on wages, education, experience and further controls are provided by the IAB employment sample, a two percent sample of all workers holding a job subject to social security contribution (see Drews 2007 and Hamann et al. 2004 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 2001. 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 is its panel structure, which allows for tracking employment histories of workers over time. Another merit is that the data are very reliable since they provide 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]

While other authors have often decided to ignore wages above this threshold and to employ a Tobit estimation strategy for censored data, we have imputed wages based

[5] The ten percent of workers earning wages above this threshold, which increases from year to year, are free to choose to either pay the maximum amount of social security payments, or to leave the public system and insure privately.

on a strategy proposed by Gartner (2005), which predicts wages above the threshold from a full set of individual characteristics. Throughout the paper wages are defined as gross daily wages, which are inflation adjusted to the 2001 Euro level. The education variable in the dataset is a six-stage indicator, which contains information on a worker's highest degree of formal education. We have corrected for inefficient and inconsistent coding of the education variable using an improved variable provided by Fitzenberger/Osikominu/Voelter (2006) and Drews (2006).

Part-time employees as well as apprentices and trainees are excluded from the data since their daily wages as well as the determinants of these wages are incommensurable to those of full time workers. From the remaining 13 million observations on about one million full time employees in Western Germany between 1977 and 2001 we draw a sample of ten percent of workers to keep the data computationally tractable.[6] Drawing the sample and dropping the observations with missing relevant data leaves us with individual panel data containing 1,312,935 observations on 98,612 persons, which we have augmented by regional data from the German Federal Statistical Office from 1995 to 2001 provided via their online service GENESIS, by regional unemployment data provided by the Federal Employment Agency, and by information on regional population density provided by the Federal Office for Regional Planning.

These regional data are available at the level of the 326 counties (*"Landkreise und kreisfreie Städte"*) in Western Germany.[7] The regional density variable is made up of a nine-stage indicator, which combines the density of the county with the population structure of the wider region a county is located in. A precise classification is provided in Table I. In the regression analysis the differentiability of the data on the location of a worker's workplace reduces from 326 to 267 counties, since in some cases small counties in the IAB dataset are either lumped together, or combined with core cities in order to impede decoding.

The descriptive evidence on individual wages in the next section covers the full period from 1977 to 2001; due to data constraints in the GENESIS data set we had to reduce the period of observation for the regression analyses to the years between 1995 and 2001, which leaves us with a set of 173,614 observations.

[6] We have drawn a ten percent sample of workers and then added information on all available years for these draws; this way we have kept the panel structure of the data and can profit from it in the subsequent analyses.

[7] Counties are equivalent to NUTSIII regions; they constitute the top-down fourth layer of a five-layer administrative system in Germany and are either made up by a single large city (*Kreisfreie Stadt*) or by an administrative unit of several smaller cities or towns (*Landkreise*).

III.2. Descriptive Evidence

Regionally augmented data on agglomeration, wages, and human capital reveal an astonishingly homogenous picture. Maps I and II show that economic activity in Germany conforms to Krugman's (1991) famous observation that "production is remarkably concentrated in space" (1991, p. 5). Map I is based on data provided by the Federal Statistical Office and contains the density of workers as measured by workers per square kilometer. Density ranges from below thirty to above 250 workers per square kilometer. Among the most densely populated areas are the cities of Munich, Stuttgart, Frankfurt, the Ruhr Area, and their respective neighboring counties. Sparsely populated counties are predominantly located in the northern part of Bavaria and in Eastern Germany. Data from the IAB sample reveal that more than 44 percent of all workers are employed in core cities above 100.000 inhabitants, which together comprise only five percent of the landmass, while about 16 percent work in rural counties, which together make up over 36 percent of the West German territory.[8] These findings are in line with the regional density indicator in Map II.

Three insights emerge from Maps III and IV with respect to the spatial and temporal distribution of wages. Firstly, although Germany is characterized by a comparatively egalitarian overall wage structure, substantial regional differences in average wages exist. In 1975 average wages in the poorest quintile of regions used to be below 45 Euros, while average wages in the richest quintile were well above 52.50 Euros. In 2001 average wage in the poorest quintile of regions ranged below 75 Euros and in rich regions above 85 Euros. Secondly, wages are related to the underlying spatial structure inasmuch as they tend to be higher in agglomerated counties and lower in rural counties. Core cities like Munich, Stuttgart, Frankfurt, the Ruhr Area, Hannover and Hamburg displayed an average wage of above 86 Euros in 2001, while average wages in rural regions like Upper Franconia or the Emsland stood at 72 Euros. This adds up to a raw urban wage premium of 19.4 percent when comparing rural to urban regions. Thirdly, a comparison of Map III and Map IV reveals a stunning persistence of the regional distribution of high-wage and low wage regions. After all, rich as well as poor regions have by and large kept their ranks over a period of 26 years. Turning to the dynamics of wages by type of region, Graph I shows that with the exception of the early 90s wages are monotonically growing; wages in all types of regions have at all times since 1975 followed the same pattern with wages in dense regions being always above those of peripheral regions. From this we suspect

[8] We are referring to counties of density levels 1 and 5 here as defined by the Federal Office for Regional Planning and reproduced in Table I, both of which are defined as core cities above 100.000 inhabitants; population and areas of rural counties are calculated on the basis of county types 4, 7, and 9.

that while in general wages are determined in the same way in all types of regions, some factors, with human capital externalities being a prime candidate, have sustainably lifted wages in urban areas above those of rural regions.

Maps V and VI display regional human capital endowments as measured by the share of workforce holding a degree from a technical college or a university. The top quintile of regions is endowed with a share of highly qualified workers of above 25 percent, while the share of highly qualified regions in the lowest quintile of regions ranges below 4 percent. The distribution of human capital is highly unequal between urban and rural regions. The share of highly qualified workers ranges at 15 percent on average in core cities and is thus about 2.5 times larger than in rural regions, where it reaches an average of 6.6 percent. Turning to the dynamics of regional human capital, Graph II shows that while the share of highly qualified workers has been rising in all types of counties due to far ranging improvements in general education opportunities, this rise has been especially pronounced in counties of type 1, 2, and 5, i.e. in urban counties. These observations indicate that higher average wages in urban areas are to some extent driven by a larger share of highly qualified workers in cities compared to rural regions. However, ascribing differences in average regional wages exclusively to skill sorting effects appears insufficient since highly qualified workers in core cities earn 125 Euros, which is about 12 percent higher than the 112 Euros earned by their equally well qualified colleagues in rural regions.

Summing up the evidence we conclude that, in accordance with numerous studies on regional development in industrialized countries, agglomeration of economic activity in German regions goes hand in hand with higher levels of wages and human capital. Descriptive evidence supports the notion that in addition to sorting effects human capital externalities may have a role to play as an explanation for regional wage differentials. The following regression analysis sheds light on the existence and the magnitude of human capital externalities as an explanatory factor for regional wage differentials while controlling for sorting effects and shifts of skills through fixed effects and instrumental variables.

III.3. Human Capital Externalities in OLS and Panel Estimates

Table II shows our results from OLS and panel estimation of equation (7). Column (I) contains OLS estimates for individual and regional determinants of individual wages excluding regional human capital. Since coefficients on individual characteristics are all in line with findings from a voluminous literature and do in principle not change between regressions we only briefly comment on them here. Age, gender, and experience all display the usual, nonlinear impact on wages, although the

coefficient of age is significant only in regressions containing individual fixed effects. As expected, private returns to education increase with degree of education. Female wages are by about twenty percent lower than men's wages and foreigners earn just about one percent more than natives all else equal. In contrast to individual characteristics, regional variables have a rather low explanatory power with respect to individual wages. In line with findings on the wage curve, regional unemployment significantly reduces wages. However, neither land prices nor amenities unfold an effect on wages. While coefficients on density have the expected sign, i.e. wages increase with the level of agglomeration, only one of them is statistically significant.
Introducing the regional share of highly qualified workers in Column (II) we find strong evidence for the existence of human capital externalities. Both coefficients of regional human capital are highly significant and an F-Test confirms their joint significance at the one percent level. The impact of regional human capital is, however, far larger for wages of highly qualified than for those of non-highly qualified workers; an increase in the regional share of highly qualified workers by one percent increases wages for highly qualified workers by .34 percent and by about .09 percent for non-highly qualified workers. A comparison of columns (I) and (II) shows that all other coefficients with the exception of those of the density variables remain largely unchanged. In line with our insights from the descriptive analysis, this observation points to a strong correlation between regional human capital and the extent of regional agglomeration. In column (III) we investigate whether regional human capital has a non-linear influence on wages as predicted by the model. The predictions from the model are not confirmed in our OLS estimates. In order to control for the sorting of workers along unobservable categories, we include individual fixed effects in columns (IV) and (V).

When controlling for workers' unobservable characteristics in a fixed effects model, the impact of human capital externalities on the wages of highly qualified workers increases to 1.1 percent while becoming insignificant with respect to wages of non-highly qualified workers. The finding that we have underestimated human capital externalities for highly qualified workers and overestimated them for non-highly qualified workers in OLS regressions is important in two respects. First of all it tells us that the extent to which workers benefit from human capital externalities depends strongly on their characteristics. We think that it is useful in this context to interpret these unobservable characteristics as a worker's receptivity, i.e. as certain character traits which enable a worker to translate benefits from surrounding human capital endowments into own productivity enhancements. Secondly, our results show that sorting effects along unobservable characteristics go in opposite directions for highly qualified and non-highly qualified workers, a finding we wish to leave for further

research here. Our results from a cubic specification are exactly in line with our expectations from the theoretical model. With respect to the wages of highly qualified workers, the impact of human capital on wages reaches a local maximum with a share of highly qualified workers of 25 percent and displays a wage depressing effect beyond that value. The size of this effect appears reasonable to us since the share of highly qualified exceeds 25 percent in only about one fifth of the regions. In line with our expectations, regional human capital has an unambiguously positive effect on the wages of non-highly qualified workers.

Three conclusions emerge. As expected from our first hypothesis, human capital externalities have an impact on the wages of highly qualified as well as non-highly qualified workers. In addition, controlling for unobservable characteristics in panel regressions suggests that a worker's receptivity is an important determinant of the extent to which human capital externalities translate into benefits for workers through productivity enhancements. Our core insight from the panel analysis is that human capital externalities display a non-linear influence on wages of highly qualified and non-highly qualified workers which we interpret in accordance with our theoretical model as resulting from a combined influence of human capital externalities and neoclassical supply effects. In order to control for these supply effects we employ an instrumental variable approach outlined in the previous section.

III.4. Human Capital Externalities: An Instrumental Variable Approach

Although changes in wages caused by supply shifts are unlikely to be of substantial size within the short period of investigation between 1995 and 2001, we are suspicious that the coefficients of regional human capital partly capture the influence of regional shifts of skills and hence are not consistent estimates of the impact of human capital externalities. When testing for potential endogeneity of the share of highly qualified workers a test on seemingly unrelated regressions rejects the hypothesis of exogeneity at the ten percent level.[9] Since we cannot rule out the possibility of endogeneity we employ the regional number of schools and the number of students attending them as instruments for regional human capital.

Statistical tests corroborate our theoretical intuition on instrumental relevance and instrumental exogeneity. The raw correlation of share of highly qualified workers per region with the number of public schools is .43, and with the number of students attending them .36. Our first stage estimates in table III(a) show that the coefficients

[9] We use a test of seemingly unrelated regressions since a common Hausman (1978) test is prone to under reject the hypothesis of exogeneity when used on clustered data (see Baum/Schaffer/Stillman 2003).

of the instruments in our preferred cubic specification are all significant at the one percent level with an adjusted R^2 ranging above ninety percent. An F-test confirms their joint relevance at the one percent level. With respect to instrumental exogeneity, a J-test of overidentifying restrictions confirms that the hypothesis of exogeneity holds for both instruments at the one percent level. Since our theoretical considerations are corroborated by these statistical results we are confident that the regional number of schools and the students attending them are relevant and exogenous instruments for regional human capital endowments.

Table III(b) shows the results from the second stage regressions which include worker fixed effects as controls for unobserved heterogeneity of workers. Our suspicion that human capital externalities might be intertwined with supply shifts of highly skilled workers are confirmed by the data. Column (VIII) shows that all coefficients of regional human capital in a cubic specification are insignificant, which implies that our instrumental variable approach eliminates non-linearities arising from supply shifts of highly qualified workers.[10] Using predicted values for regional human capital from our first stage we then estimate the influence of human capital externalities in a linear equation. Column (VII) shows that a rise in the regional share of highly qualified workers by one percent increases wages of highly qualified workers by nearly 1.8 percent, compared to .9 in the panel analysis without instruments. With respect to non-highly qualified workers, regional human capital externalities are slightly smaller with a one percent increase in regional human capital raising wages by .6 percent. Thus, while human capital externalities have a significant influence on wages of highly qualified and non-highly qualified workers alike, their impact is about three times larger for the former group. This finding not only runs counter to our expectation of an equal effect derived from the model, but also to Moretti's (2004b) finding for the US that wage effects from human capital externalities decrease with level of education. We suspect that collective wage agreements in Germany, which set wages for the majority of non-highly qualified workers but only for a minority of highly qualified workers, might suppress effects from regional human capital externalities on wages of non-highly qualified workers (see Haisken-DeNew/Schwarze 1997 on the educational scope of collective agreements).

III.5. Robustness Checks

In table IV we investigate whether our findings on the existence of human capital externalities hinge on our choice of the regional share of highly qualified workers as

[10] In line with Kelejian (1971), Newey (1990), and Carroll et al. (2004) we have predicted the polynomials of the share of highly qualified workers from the same first stage specification we used for the non-exponential term.

an indicator for regional human capital. We therefore rerun our OLS and panel regressions for alternative measures of regional human capital endowments, i.e. for regional average education, the regional kurtosis of education, and the regional Hirschman-Herfindahl index of education. As outlined above, each measure of regional human capital is subject to specific assumptions with respect to the sources of human capital externalities. While the regional share of highly qualified workers relates human capital externalities to workers with an academic degree, average education takes the overall level of schooling into account. Using the kurtosis and the Hirschman-Herfindahl index addresses the suspicion that human capital externalities are rooted in the concentration of workers with the same type of education.

Table IV shows that all indices identify strong human capital externalities for wages of highly qualified workers, but provide only very weak evidence of an effect of human capital externalities on wages of non-highly-qualified workers. These results from OLS and panel estimates are in line with our findings for the share of highly qualified workers as an index for regional human capital. The negative signs on the kurtosis and the Hirschman-Herfindahl index require a word of explanation. In our interpretation, both indices in practice measure the regional concentration of workers with a high school degree and subsequent vocational training, since these workers constitute about seventy percent of the German workforce. An increasing concentration of this type of workers in a regional workforce is strongly correlated with decrease of highly qualified workers therein. The decidedly negative impact of the concentration measures might thus stem from a reduced share of highly qualified workers in the regional workforce, which indicates that this educational group, rather than the simple concentration of any other education type, is the underlying source of human capital externalities. This interpretation is in line with findings from the United States, where human capital externalities are frequently assigned to the existence of a regional 'creative class', i.e. to a significant share of academics in the population (Florida 2002).

In order to control for supply shifts of skills we again employ our instrumental variable approach using the regional number of schools and of students as instruments. Table V and VI contain the first and second stage regressions. The set of first stage regressions indicates that the instruments are highly relevant for all our indicators. All instruments are significant at the one percent level in a cubic specification and F-tests strongly confirm their joint significance. The results from the second stage in table VI confirm the results from our previous analysis based on the regional share of highly qualified workers. Again, the coefficients of the impact of human capital externalities on the wages of highly qualified and non-highly qualified workers substantially increase in size when we employ an instrumental variable

approach. In line with previous results, human capital externalities are about three times larger for highly qualified than for non-highly qualified workers. Although this finding suggests that the impact of human capital externalities differs with respect to a worker's educational background we cannot rule out the possibility that this result is rooted in different processes of wage determination for highly qualified and non-highly qualified workers. Our findings also run counter to our second hypothesis from which we expected to find human capital externalities to be overestimated for non-highly qualified workers in OLS and panel regressions. Our results, in contrast, consistently show that human capital externalities are underestimated for highly qualified and non-highly qualified workers alike. This finding casts doubt on the assumption of imperfect substitutability between both types of workers being appropriate. Our findings rather suggest that highly qualified workers compete with both types of workers for jobs; thus, an increase of the number of highly qualified workers depresses wages of both types of workers alike, a finding which is reflected in our general underestimation of human capital externalities. Thus, non-highly qualified workers do not benefit from relative scarcity if the share of highly qualified workers increases due to competition between both groups; this notion is consistent with our lack of evidence for an overestimation of human capital externalities for either type of worker. This interpretation of our findings is in line with results from a broad literature on asymmetric substitutability between workers of different skill groups (see e.g. Katz/Murphy 1992).

Three basic insights emerge from employing alternative indicators of human capital with respect to human capital externalities, supply effects, and their respective importance for workers of different educational backgrounds. For all indicators of regional human capital we find strong evidence that human capital externalities matter for highly qualified and non-highly qualified workers alike, though we cannot say with certainty whether this impact is of equal size for both types of workers. Comparing our results from different indicators suggests that human capital externalities are first and foremost rooted in the extent to which a regional workforce is composed of highly-qualified workers, a finding which is in line with empirical insights for the United States. Finally, our finding that human capital externalities are underestimated for highly qualified and non-highly qualified workers alike makes us believe that in contrast to our theoretical model, substitution between both types of workers are not symmetric, but that supply shifts of highly qualified workers depress wage of both types of workers alike, since highly qualified workers can substitute non-highly qualified workers and thereby eliminate the latter group's advantage from relative scarcity.

Our final robustness check is based on the possibility that other regional variables included in our analysis might have a differential impact on the wages of highly and non-highly qualified workers. Since in our specification we have not allowed these variables to exert different influences on different types of workers, we might have forced our human capital coefficients to take up group-specific influences from other regional variables. In order to account for this we split up unemployment, amenities, and land price levels into their respective impact on wages of highly and non-highly qualified workers and re-estimate our panel regressions. Table VII shows that the impact of human capital externalities remains unaltered for all indices. What we do observe, though, is that the coefficients of most other regional variables change considerably. Interestingly, unemployment unfolds a substantially higher impact on the wages of highly qualified than on the wages of non-highly qualified workers. While this observation calls for a deeper investigation of the wage curve differentiated by skill group, it also gives rise to the suspicion that the system of collective agreements protects wages of non-highly qualified workers from regional unemployment pressure, which is in line with our impression that it prevents their wages to fully adapt to productivity enhancing human capital externalities. While the role of land prices and amenities remains ambiguous, we now find strong evidence of regionalized increasing returns arising from the density of economic activity. We leave the question to which extent regional variables unfold a differential impact on different types of workers for future research and turn to our last exercise, i.e. an analysis on whether industries are to a different extent shaped by human capital externalities.

IV. Human Capital Externalities by Industry

Microeconomic theory regards human capital externalities as being rooted either in processes of knowledge exchange between agents, or in firms' investment behavior with respect to physical capital. Since the importance of knowledge and physical capital varies widely between industries, the extent to which each industry provides a fertile soil for human capital externalities is likely to differ accordingly. In our analysis we have up to now treated human capital externalities as being independent of the type of industry they occur in. While we have of course controlled for the extent to which a worker's affiliation to an industry influences wages, for example through industry-wide collective agreements, by not differentiating human capital externalities by industry we have implicitly assumed that they unfold their impact unconditional on the industry a worker is employed in. However, Krueger/Summers'

(1988) finding of substantial wage differences between industries encourages an analysis on whether these are at least partly attributable to an inter-industry variance of human capital externalities (see Haisken-DeNew/Schmidt 1997 for inter-industry wage differentials in Germany). The remaining part of the paper therefore focuses on the extent to which the size of human capital externalities differs between industries.

With respect to workers' industry affiliation the data set enables us to differentiate between sixteen industries. We have rerun regression the panel regressions for the impact of regional human capital externalities on wages of highly qualified and non-highly qualified workers for each of the sixteen industries with and without instrumental variables. This leaves us with 32 results on sixteen industries contained in table VIII.

It turns out that in panel regressions without instruments the regional share of human capital has an impact on the wages of highly qualified workers in eleven out of sixteen industries. This impact always increases when we employ instrumental variables and becomes significant for all sixteen industries. Things are different when it comes to the impact of human capital externalities on the wages of non-highly qualified workers. In panel regressions we obtain only six significant coefficients, which further reduce to five when we employ instrumental variables. We do not find a clear pattern of changes in coefficient size between panel and instrument regressions. Even more puzzling is the occurrence of negative signs, as well as the frequent change of signs between panel and instrument regressions.

Our finding that within industries the effect from human capital externalities increases for highly qualified workers but is basically absent for non-highly qualified workers stands in stark contrast to our previous finding that regional human capital externalities affect both types of workers. However, the literature on the industrial scope of human capital externalities provides a suggestive explanation. In this literature, the debate on whether knowledge spillovers occur within industries or between them has a longstanding tradition. While adherents of Marshall-Arrow-Romer externalities contend that knowledge spillovers mainly arise through learning within industries (e.g. Wheaton/Lewis 2002, Jacobs 1961, 1969) and others argue that knowledge exchange between industries is more productivity enhancing than within industries. Our results indicate that the extent to which human capital externalities occur within or between industries is influenced by the educational background of workers. While we find within-industry human capital externalities to matter most for highly skilled workers, the impact of human capital externalities on the wages of non-highly qualified workers seems to work mainly through between-

industry effects. Our cautious guess is that our results are driven by different types of externalities being of prime importance for highly qualified and non-highly qualified workers. Thus, highly qualified workers first and foremost benefit from knowledge spillovers arising from frequent interaction with colleagues who are employed in the same industry. In this case, the intra-industry share of highly qualified workers is the frame of reference within which externalities evolve through communication and intellectual exchange. For non-highly qualified workers, in contrast, pecuniary externalities play a dominant role. Pecuniary externalities arise if firms invest in physical capital in anticipation of the qualification level of their future work force. It appears reasonable for us to assume that firms take overall regional human capital endowments rather than only regional human capital endowments within their own industry as a focal point when deciding on future investments. While the idea that pecuniary and technological human capital externalities differ in their different industrial scope and in their applicability to different types of workers is very well suited to explain our results, it certainly remains suggestive here. Both notions have to the best of our knowledge not yet been investigated in the theoretical and empirical literature and remain worthwhile objects of research.

Since the analysis reveals that within-industry human capital externalities have a highly significant impact on the wages of highly qualified workers in all industries we focus on highly qualified workers in order to further investigate which industries are predominantly shaped by human capital externalities.

The range of social returns to human capital extends from 1.28 in Social Security Services to 6.66 in the Production of Consumption Goods. An increase of the share of highly qualified workers by one percent thus increases wages between one and nearly seven percent in our sixteen industries. The most ostensible finding emerging from table VIII is the clear division between manufacturing and services with respect to the size of externalities. The average magnitude of the wage effects of human capital spillovers amounts up to 4.25 percent in manufacturing, while it stands at 2.11 percent on average in services. A potential explanation relates to differences in knowledge and physical capital intensity between manufacturing and the service sector. We do not know from the data whether manufacturing or the service sector is more knowledge intensive and it is therefore impossible to tell whether knowledge spillovers are more pronounced in one of them. The issue is, however, more straightforward with respect to physical capital investments, which can reasonably be assumed to play a more far important role in manufacturing compared to the service sector. It is therefore likely that pecuniary externalities in manufacturing explain a large part of the difference to which human capital externalities occur in manufacturing and in the service sector. This finding encourages the development of

empirical methods as well as the generation of datasets which together are capable of discriminating between pecuniary and technological externalities, an undertaking we deem has not been followed thoroughly enough given the preliminary evidence on the substantial role this distinction has for the explanation of systematic differences in human capital externalities between workers and industries alike.

V. Conclusion

Regions in Western Germany differ remarkably with respect to their human capital endowments and average wage levels. Relying on a model of increasing social returns to human capital we have investigated the extent to which human capital externalities are a driving force behind regional wage differentials in Germany. Various insights have emerged.

Human capital externalities are an important wage determining factor. Employing the regional number of public schools and of students attending them as instruments for regional human capital endowments we find that the regional share of highly qualified workers increases wages by 1.8 percent for highly qualified workers and by .6 percent for non-highly qualified workers. This result is robust to the inclusion of a wide array of individual and regional variables, as well as individual and regional fixed effects. Employing alternative indicators for regional human capital endowments we demonstrate that human capital externalities are to a large extent rooted in the regional share of highly qualified workers.

Our instrumental variable approach enables us to disentangle the impact of human capital externalities on wages from that of supply shifts in human capital. We find human capital externalities to be underestimated by about fifty percent in simple panel regressions not only for highly qualified workers but, in contrast to our expectations, also for non-highly qualified workers. From this we infer that while an increase of the regional share of highly qualified workers depresses wages for both highly qualified and non-highly qualified workers alike due to a shared labor market, this neoclassical supply effect is overcompensated by human capital externalities impacting on the wages of both types of workers.

An investigation of regional human capital externalities by industry shows that highly qualified workers mainly benefit from intra-industry human capital externalities, while wages of non-highly qualified workers are more affected by human capital externalities occurring between industries. This finding indicates that knowledge externalities arising within industries through processes of learning are of greater importance for highly qualified workers than for non-highly qualified workers,

while the latter are predominantly affected by pecuniary externalities arising from firms' investment decisions based on overall regional human capital endowments.

The importance of the distinction between knowledge externalities and pecuniary externalities is corroborated by our finding that human capital externalities are on average fifty percent smaller in the service sector compared to manufacturing. While we cannot assess the relative size of knowledge externalities, greater physical capital endowments in manufacturing compared to service make us believe that pecuniary externalities are a driving force for the size difference in human capital externalities between both sectors.

Our finding of systematic differences of human capital externalities between educational groups, as well as between industries, should encourage research efforts in one main direction. Empirical insights into the microeconomic mechanics of human capital externalities are necessary in order to understand the relative magnitude of technological and pecuniary externalities and the ways through which they unfold benefits for different actors. Theoretical models in this field are far ahead of empirical insights and it remains to be hoped that the accessibility of new microeconomic datasets enables researches to shed further light on the mechanisms through which regional human capital and economic prosperity are connected. A promising example is provided by Jaffe (1989), who investigate the extent to which innovation is related to regional knowledge spillovers by using localized patent data.

The core message to policy makers arising from our findings is that regional human capital endowments have an important role to play for processes of regional development. The formation of an educated workforce should therefore be a core strategy of regional policy. However, two caveats apply, both of which touch on the issue of equality. Any policy being committed to increasing the share of highly qualified workers among its workforce should be aware that benefits from human capital externalities tend to more than proportionally accrue to highly qualified workers than to non-highly qualified workers. Thus, this type of regional policy might at least temporarily increase intraregional inequality and it depends on the extent to which the gains from higher productivity are passed on to non-highly qualified workers that the tide of human capital externalities lifts all boats. Secondly, it should be noted that highly qualified and non-highly qualified workers exhibit different propensities of migration with the former being more mobile than the latter. With rising wages in human capital intensive regions patterns of selective migration are prone to induce a process of interregional divergence. In a dynamic perspective an increasing spatial agglomeration of highly qualified workers in regions characterized by substantial human capital externalities will result in regional divergence and interregional inequality. Such a process is hardly in line with the German objective of

establishing comparable standards of living in all regions (see Tetsch 1994). An economic policy regime aiming to strike the balance between fostering prosperity through human capital externalities and promoting equality at the same time is therefore well advised to promote a regional concentration of human capital while at the same time "to increase the strength of the spread effects of the development impulses as between regions and between occupations" (Myrdal 1954: 81).

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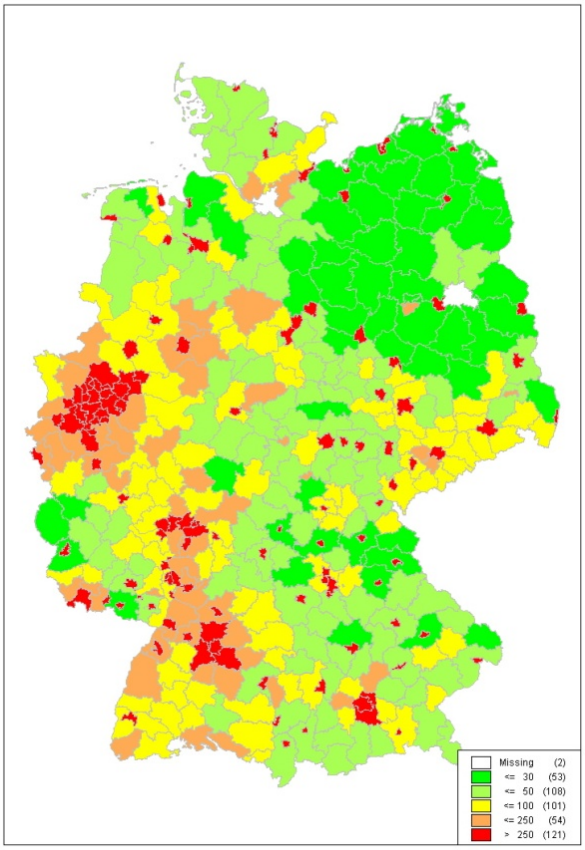
Appendix

Table I – Classification of Counties, Federal Office for Regional Planning

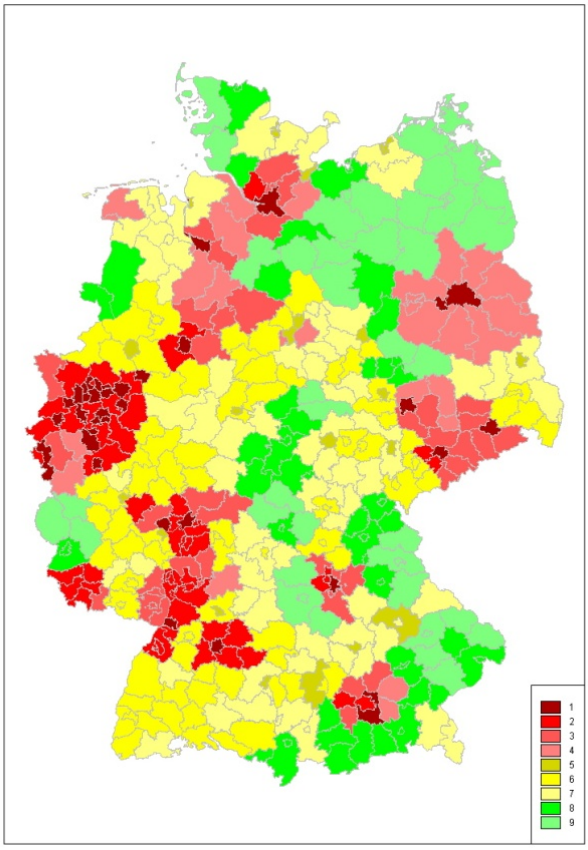
	Type of wider region a county is located in					
	Agglomerated Region		Slightly Agglomerated Region		Rural Region	
Type of County	1	Core city in agglomerated region	5	Core city in slightly agglomerated area		
	2	Very dense county in agglomerated region				
	3	Dense county in agglomerated region	6	Dense county in slightly agglomerated region	8	Dense county in rural region
	4	Rural county in agglomerated region	7	Rural county in slightly agglomerated region	9	Rural county in rural region

Notes: Agglomerated Regions are classified as such by the existence of a core city with more than 300.000 inhabitants and/or by a population density of above 300 inhabitants per sqkm; Slightly Agglomerated Regions contain a core city with more than 100.000 inhabitants and/or are characterized by a population density above 150 inhabitants per sqkm; Rural Regions neither contain a core city of 100.000 inhabitants, nor does their population density exceed 150 inhabitants per sqkm.

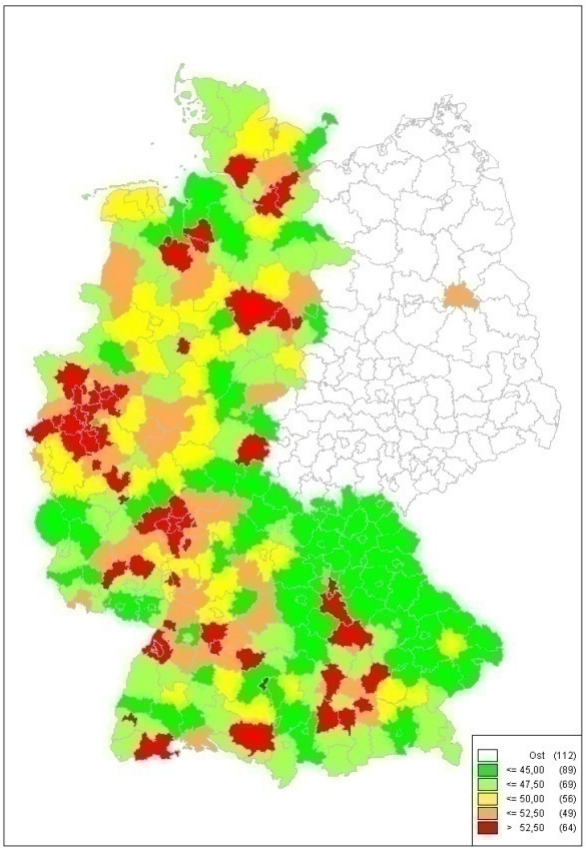
Map I – Number of Workers per sqkm by County, Average 2001



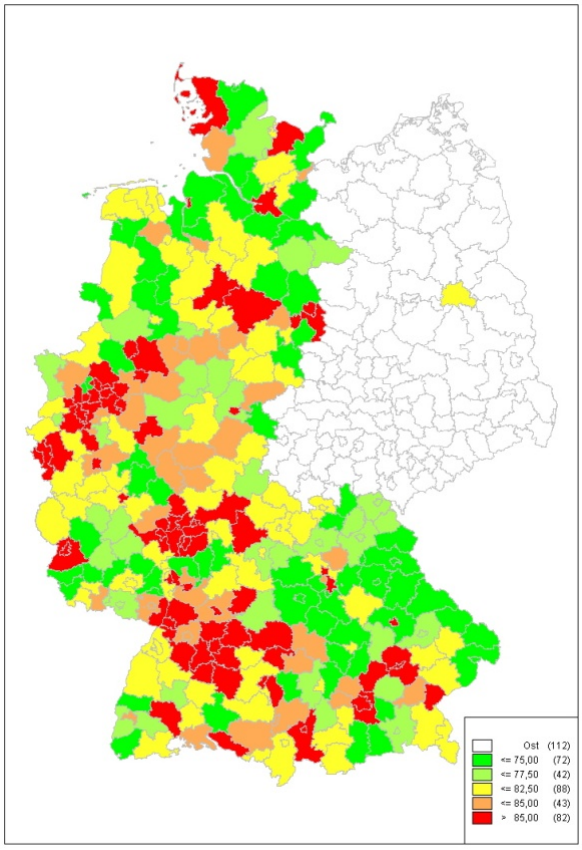
Map II – Regional Population Density, Indicator by the Federal Office for Regional Planning



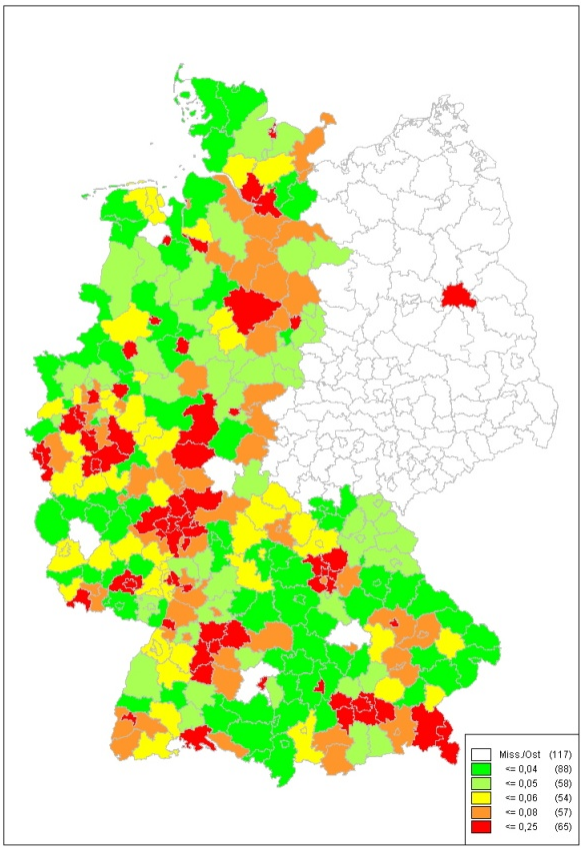
Map III – Daily Gross Wages by County, Averages 1975



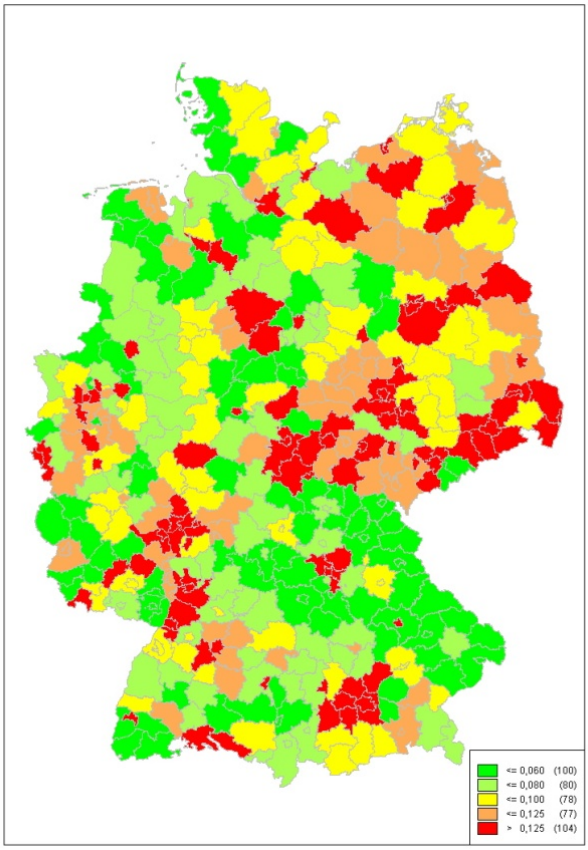
Map IV – Daily Gross Wages by County, Averages 2001



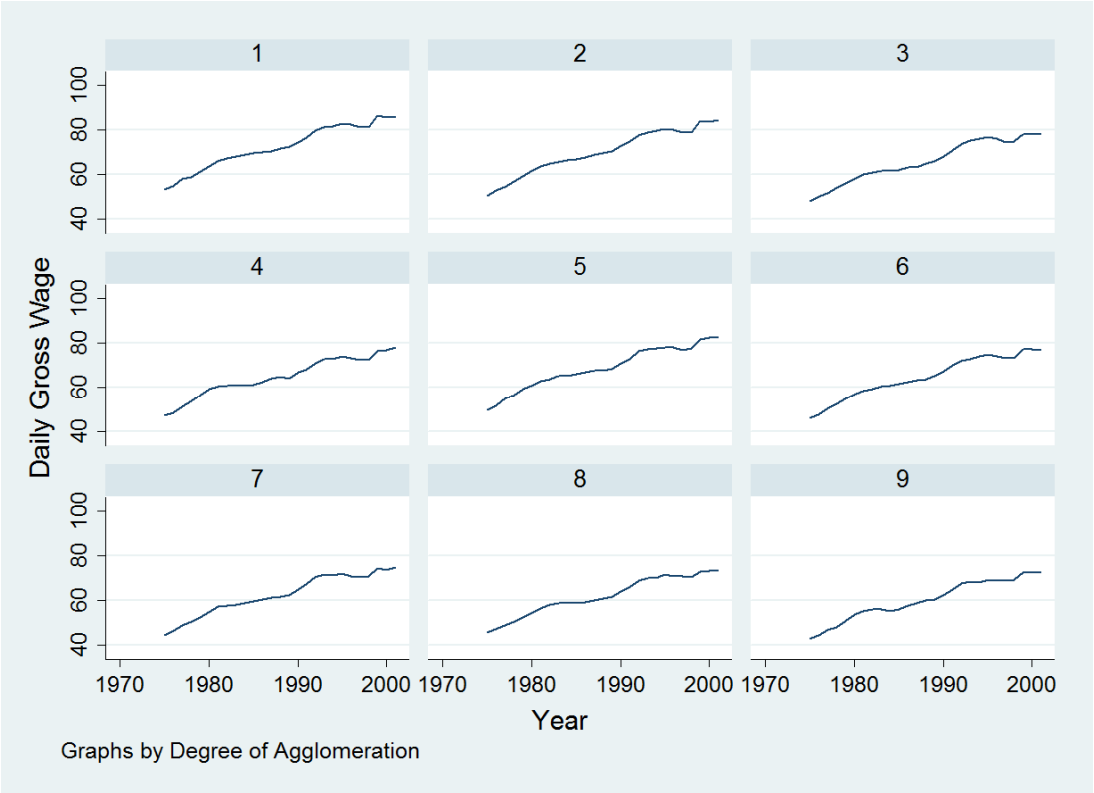
Map V - Educational Attainment by County, as % of Highly Qualified Workers, 1992



Map VI - Educational Attainment by County, as % of Highly Qualified Workers, 2001



Graph I – Dynamics of Daily Gross Wages (deflated), by Degree of Density



Graph II – Average Share of Highly Qualified Workers, by Degree of Density

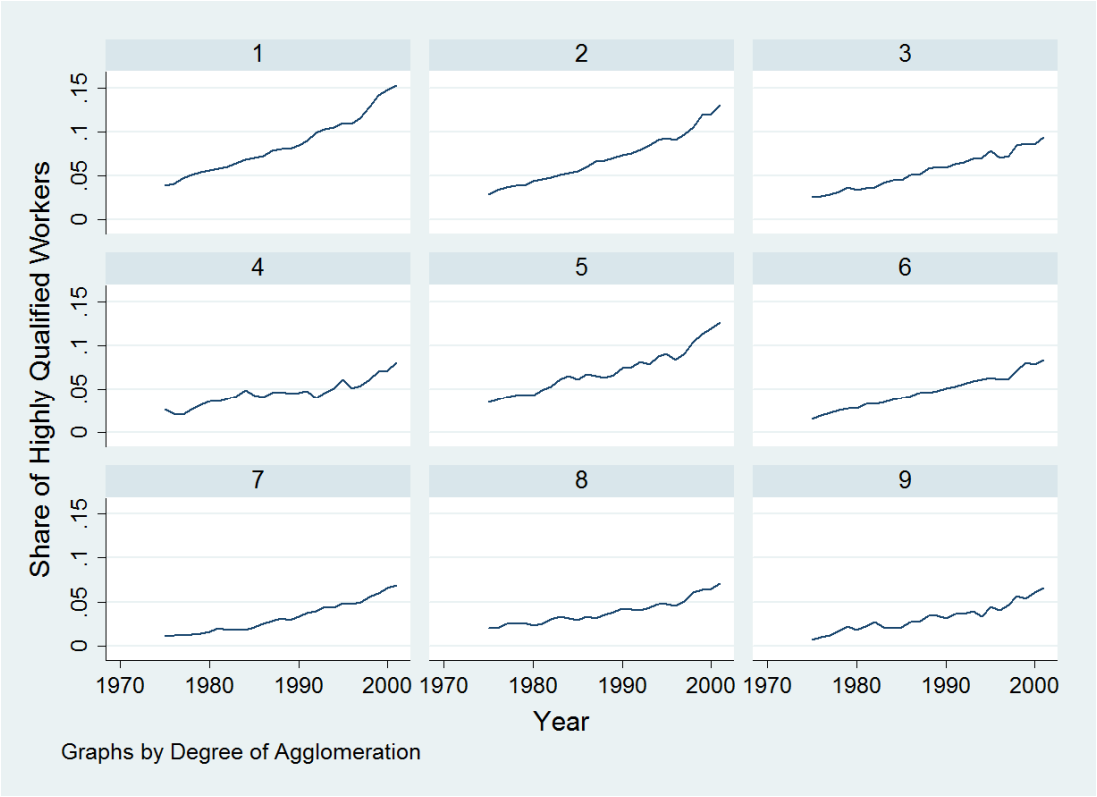


Table II – OLS and Panel Estimates

	Dependent Variable: ln($wage_i$)					
		(I)	(II)	(III)	(IV)	(V)
Individual Wage Determinants	Age	.001	.001	.001	.021	.021
		(.0007)	(.0007)	(.0007)	(.001)***	(.001)***
	Age^2	-.00004	-.00004	-.00004	-.0002	-.0002
		(.000008)***	(.000008)***	(.00008)***	(.00001)***	(.00001)***
	Sex	-.209	-.209	-.210	-	-
		(.003)***	(.003)***	(.003)***		
	Nation	.006	.006	.006	-	-
		(.0005)***	(.0005)***	(.0005)***		
	Tenure	.014	.014	.014	.003	.003
		(.0004)***	(.0004)***	(.0004)***	(.0004)***	(.0004)***
	Tenure^2	-.0005	-.0005	-.0005	-.0001	-.0001
		(.00002)***	(.00002)***	(.00002)***	(.00002)***	(.00002)***
	Experience	.023	.023	.023	.009	.009
		(.0005)***	(.0005)***	(.0005)***	(.0008)***	(.0008)***
	Experience^2	-.0004	-.0004	-.0004	-.0004	-.0004
		(.00002)***	(.00002)***	(.00002)***	(.00002)***	(.00002)***
	No Formal Degree	-.284	-.254	-.303	.015	.014
		(.005)***	(.009)***	(.022)***	(.017)	(.017)
	V/H/R-Schule and Vocational Training	-.217	-.187	-.236	.048	.047
		(.004)***	(.009)***	(.022)***	(.017)***	(.017)***
	Gymnasium	-.171	-.140	-.189	Ref.	Ref.
		(.010)***	(.013)***	(.024)***		
	Gymnasium and Vocational Training	-.139	-.109	-.158	.099	.099
		(.005)***	(.009)***	(.022)***	(.016)***	(.016)***
	Technical College	Ref.	Ref.	Ref.	.086	.185
					(.019)***	(.024)***
	University	.098	.095	.096	.177	.276
		(.005)***	(.005)***	(.005)***	(.019)***	(.024)***
Regional Human Capital	Share HQ * D^{HQ}	-	.339	-.942	.865	-1.50
			(.072)***	(.583)*	(.051)***	(.380)***
	ShareHQ^2 * D^{HQ}	-	-	6.22	-	13.5
				(4.53)		(2.71)***
	ShareHQ^3 * D^{HQ}	-	-	-5.63	-	-20.6
				(10.4)		(5.91)***
	Share HQ * D^{NHQ}	-	.089	-.299	-.015	-.289
			(.033)***	(.119)**	(.025)	(.092)***
	ShareHQ^2 * D^{NHQ}	-	-	2.52	-	1.87
				(1.08)**		(.823)**
	ShareHQ^3 * D^{NHQ}	-	-	-3.41	-	-2.68
				(2.94)		(2.13)
Alternative Explanations for Urban Wage Premia	Unemployment Rate	-.003	-.003	-.003	-.004	-.004
		(.001)***	(.001)***	(.001)***	(.001)***	(.001)***
	Land Price Level	-.002	-.002	-.003	-.001	-.002
		(.002)	(.002)	(.002)	(.001)	(.002)
	Amenities	$4.36*10^{-7}$	$-2.43*10^{-7}$	$-1.65*10^{-6}$	$1.57*10^{-6}$	$4.80*10^{-7}$
		$(1.52*10^{-7})$	$(1.53*10^{-6})$	$(1.04*10^{-6})$	$(.71*10^{-6})$**	$(7.31*10^{-7})$
	Density 1	.040	.005	-.072	.133	.123
		(.080)	(.072)	(.056)	(.047)***	(.047)***
	Density 2	.101	.032	-.076	.079	.080
		(.078)	(.074)	(.066)	(.053)	(.053)
	Density 3	.066	.032	-.039	.028	.024
		(.081)	(.073)	(.058)	(.049)	(.049)
	Density 4	.004	-.031	-.107	Ref.	Ref.
		(.081)	(.073)	(-056)		
	Density 5	-.067	-.101	-.168	.093	.091
		(.077)	(.069)	(.053)***	(.055)*	(.055)*
	Density 6	-.027	-.066	-.134	-.016	-.023
		(.077)	(.070)	(.054)**	(.054)	(.054)
	Density 7	-.059	-.061	-.056	.069	.058
		(.014)***	(.014)***	(.013)***	(.067)	(.067)
	Density 8	.027	-.017	-.081	-.106	-.105
		(.081)	(.074)	(.058)	(.054)**	(.054)**
	Density 9	Ref.	Ref.	Ref.	-.069	-.026
					(.059)	(.060)
Controls	Occupation Dummy	Yes	Yes	Yes	Yes	Yes
	Industry Dummy	Yes	Yes	Yes	Yes	Yes
	Year Dummy	Yes	Yes	Yes	Yes	Yes
	Region Dummy	Yes	Yes	Yes	Yes	Yes
	Worker Fixed Effects	No	No	No	Yes	Yes
	No. Observations	173,614	173,614	173,614	173,614	173,614
	No. Groups	-	-	-	39,758	39,758
	Prob(ShareHQ)=0	-	0.0000	0.0000	0.0000	0.0000
	Adj. R^2 (overall)	.4795	.4796	.4797	.2849	.2849

Notes: All standard errors are cluster corrected by regional ShareHQ; 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; variables *Sex* and *Nation* are dropped in panel regressions due to perfect multicollinearity with worker fixed effects; *Ref.* indicates reference category for dummy variables.

Table III(a) – IV-Estimates: First Stage

	Dependent Variable: Share of HQ	
		(VI)
	Age	-
	Age^2	-
	Tenure	-
	Tenure^2	-
	Experience	-
	Experience^2	-
	No Formal Degree	-
	V/H/R-Schule and Vocational Training	-
	Gymnasium	-
	Gymnasium and Vocational Training	-
	Technical College	-
	University	-
Instrumental Variables	No of Students	-.00001 (.0000002)***
	No of Students^2	$1.73*10^{-10}$ ($3.40*10^{-12}$)***
	No of Students^3	$-6.49*10^{-16}$ ($1.61*10^{-17}$)***
	No of Secondary Schools	.002 (.00007)***
	No of Secondary Schools^2	-.00001 ($3.25*10^{-7}$)***
	No of Secondary Schools^3	$1.49*10^{-8}$ ($4.20*10^{-10}$)***
Exogenous Regional Variables	Unemployment Rate	-.0006 (.00008)***
	Land Price Level	.0007 (.0002)***
	Amenities	$3.40*10^{-6}$ ($7.97*10^{-8}$)***
	Density 1	.265 (.007)***
	Density 2	.078 (.009)***
	Density 3	.089 (.002)***
	Density 4	.061 (.002)***
	Density 5	.077 (.003)***
	Density 6	.090 (.002)***
	Density 7	.064 (.004)***
	Density 8	.171 (.002)***
	Density 9	Ref.
Controls	Occupation Dummy	No
	Industry Dummy	No
	Year Dummy	Yes
	Region Dummy	Yes
	Worker Fixed Effects	No
	No. Observations	173,614
	Prob(Instr.=0)	0.0000
	Adj. R^2	.9167

Table III(b) – IV-Estimates: Second Stage

	Dependent Variable: ln($wage_i$)		
		(VII)	(VIII)
Individual Wage Determinants	Age	.019 (.001)***	.019 (.002)***
	Age^2	-.0002 (.00001)***	-.0002 (.00001)***
	Tenure	.003 (.0004)***	.003 (.0004)***
	Tenure^2	-.0001 (.00002)***	-.0001 (.00002)***
	Experience	.009 (.0008)***	.009 (.0008)***
	Experience^2	-.0004 (.00002)***	-.0004 (.00002)***
	No Formal Degree	.013 (.017)	.013 (.017)
	V/H/R-Schule and Vocational Training	.046 (.017)***	.046 (.017)***
	Gymnasium	Ref.	Ref.
	Gymnasium and Vocational Training	.099 (.016)***	.099 (.016)***
	Technical College	.049 (.019)***	.019 (.029)
	University	.139 (.019)***	.109 (.029)***
Regional Human Capital Predicted From 1st Stage	Share HQ * D^{HQ}	1.79 (.165)***	1.95 (2.00)
	ShareHQ^2 * D^{HQ}	-	-5.17 (13.2)
	ShareHQ^3 * D^{HQ}	-	18.1 (28.6)
	Share HQ * D^{NHQ}	.601 (.157)***	-.378 (1.93)
	ShareHQ^2 * D^{NHQ}	-	5.43 (12.5)
	ShareHQ^3 * D^{NHQ}	-	-9.16 (26.8)
Alternative Explanations for the Urban Wage Premium	Unemployment Rate	-.003 (.0009)***	-.003 (.0009)***
	Land Price Level	-.002 (.002)	-.002 (.002)
	Amenities	$-1.17*10^{-6}$ ($9.38**10^{-7}$)	$-2.10*10^{-6}$ ($1.33*10^{-6}$)
	Density 1	.138 (.047)***	.114 (.060)*
	Density 2	.058 (.053)	.060 (.054)
	Density 3	.028 (.049)	.017 (.052)
	Density 4	Ref.	Ref.
	Density 5	.075 (.054)	.077 (.056)
	Density 6	-.011 (.054)	-.025 (.058)
	Density 7	.085 (.067)	.082 (.068)
	Density 8	-.189 (.056)***	-.170 (.063)***
	Density 9	.079 (.069)	.112 (.076)
Controls	Occupation Dummy	Yes	Yes
	Industry Dummy	Yes	Yes
	Year Dummy	Yes	Yes
	Region Dummy	Yes	Yes
	Worker Fixed Effects	Yes	Yes
	No. Observations	173,614	173,614
	No. Groups	39,758	39,758
	Adj. R^2 (overall)	.2764	.2800

Notes: All standard errors are cluster corrected by regional ShareHQ; 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; First Stage Regression contains regional variables only; *Ref.* indicates reference category for dummy variables.

Table IV – OLS and Panel Estimates: Robustness Checks (I)

	Dependent Variable: ln(wage$_i$)						
		(IX)	(X)	(XI)	(XII)	(XIII)	(XIV)
Regional Human Capital	AvEducation * D^{HQ}	.039 (.008)***	.108 (.006)***	-	-	-	-
	AvEducation * D^{NHQ}	.005 (.004)	-.008 (.003)**	-	-	-	-
	Kurtosis * D^{HQ}	-	-	-.003 (.001)***	-.010 (.0009)***	-	-
	Kurtosis * D^{NHQ}	-	-	-.0001 (.0002)	.0003 (.0003)	-	-
	Herfindahl * D^{HQ}	-	-	-	-	-.121 (.040)***	-.394 (.031)***
	Herfindahl * D^{NHQ}	-	-	-	-	-.029 (.015)*	-.005 (.013)
Alternative Explanations for the Urban Wage Premium	Unemployment Rate	-.003 (.001)**	-.004 (.0009)***	-.003 (.001)**	-.004 (.0009)***	-.003 (.001)**	-.004 (.0009)***
	Land Price Level	-.003 (.002)	-.002 (.002)	-.002 (.003)	-.001 (.002)	-.002 (.003)	-.001 (.002)
	Amenities	$-5.67*10^{-8}$ $(1.42*10^{-6})$	$1.67*10^{-6}$ $(.71*10^{-6})$**	$3.63*10^{-7}$ $(1.51*10^{-6})$	$2.18*10^{-6}$ $(.70*10^{-6})$*	$1.50*10^{-7}$ $(1.47*10^{-6})$	$1.87*10^{-6}$ $(.71*10^{-6})$*
	Density 1	.016 (.075)	.129 (.047)***	.061 (.079)	.026 (.050)	.024 (.078)	.134 (.047)***
	Density 2	.062 (.076)	.079 (.053)	-.0004 (.084)	.093 (.055)*	.073 (.077)	.082 (.053)
	Density 3	.045 (.076)	.027 (.049)	-.031 (.079)	.043 (.053)	.052 (.079)	.026 (.049)
	Density 4	-.019 (.076)	Ref.	-.019 (.079)	-.112 (.054)**	-.013 (.079)	Ref.
	Density 5	-.088 (.072)	.089 (.054)*	.091 (.078)	.038 (.054)*	.074 (.077)	.092 (.054)*
	Density 6	-.051 (.073)	-.018 (.054)	-.008 (.080)	.008 (.061)	-.047 (.076)	-.013 (.054)
	Density 7	-.057 (.014)***	.057 (.067)	.028 (.075)	.093 (.069)	-.060 (.013)	.084 (.068)
	Density 8	-.0002 (.077)	-.078 (.054)	-.035 (.072)	-.075 (.058)	.009 (.079)***	-.093 (.054)
	Density 9	Ref.	-.082 (.059)	Ref.	Ref.	Ref.	-.088 (.059)
Controls	Occupation Dummy	Yes	Yes	Yes	Yes	Yes	Yes
	Industry Dummy	Yes	Yes	Yes	Yes	Yes	Yes
	Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
	Region Dummy	Yes	Yes	Yes	Yes	Yes	Yes
	Worker Fixed Effects	No	Yes	No	Yes	No	Yes
	No. Observations	173,614	173,614	173,614	173,614	173,614	173,614
	No. Groups	-	39,758	-	39,756	-	39,758
	Adj. R^2 (overall)	.4796	.2840	.4794	.2850	.4795	.2847

Notes: Regressions are augmented by the familiar full set of determinants of individual productivity, which are not shown here since they display the expected usual properties; all standard errors are cluster corrected by regional ShareHQ; 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; variables *Sex* and *Nation* are dropped in panel regressions due to perfect multicollinearity with worker fixed effects; *Ref.* indicates reference category for dummy variables.

Table V – IV Panel-Estimates: First Stage, Robustness Check

	Dependent Variable:	Average Level of Education	Kurtosis of Education	Herfindahl Index of Education
		(XX)	(XXI)	(XXII)
Instrumental Variables	No of Students	-.00008 (.000002)***	.0004 (.00003)***	.00002 (.48*10^{-6})***
	No of Students^2	1.10*10^{-9} (.03*10^{-9})***	-9.40*10^{-9} (.37*10^{-9})***	-2.87**10^{-10} (.07**10^{-10})***
	No of Students^3	-3.91*10^{-15} (.13*10^{-15})***	4.22*10^{-14} (.18*10^{-14})***	1.04*10^{-15} (.03**10^{-15})***
	No of Secondary Schools	.012 (.0006)***	-.089 (.008)***	-.020 (.0001)***
	No of Secondary Schools^2	-.00006 (.000003)***	.0005 (.00003)***	.00001 (.000006)***
	No of Secondary Schools^3	8.69*10^{-8} (.34*10^{-8})	-4.88*10^{-7} (.46*10^{-7})***	1.62*10^{-8} (.08*10^{-8})***
Controls	Regional Variables	Yes	Yes	Yes
	Year Dummy	Yes	Yes	Yes
	Region Dummy	Yes	Yes	Yes
	No. Observations	173,614	173,614	173,614
	Prob(Instr=0)	0.0000	0.0000	0.0000
	Adj. R^2	.9203	.8010	.9067

Notes: Standard errors in parentheses; ***, ** and * indicate significance at the 1% level, the 5% level and the 10% level respectively; regressions contain the full set of regional variables familiar from Table III, which are not reported here.

Table VI – IV Panel-Estimates: Second Stage, Robustness Check

	Dependent Variable: ln(wage$_i$)			
		(XXIII)	(XXIV)	(XXV)
Regional Human Capital Predicted From 1st Stage	Average Education * D^{HQ}	.249 (.025)***	-	-
	Average Education * D^{NHQ}	.098 (.025)***	-	-
	Kurtosis * D^{HQ}	-	-.026 (.003)***	-
	Kurtosis * D^{NHQ}	-	-.006 (.003)	-
	Herfindahl * D^{HQ}	-	-	-.925 (.102)***
	Herfindahl * D^{NHQ}	-	-	-.384 (.097)***
Alternative Explanations for the Urban Wage Premium	Unemployment Rate	-.004 (.0009)***	-.003 (.001)***	-.002 (.001)**
	Land Price Level	-.005 (.002)***	-.002 (.002)	-.001 (.002)
	Amenities	1.45*10^{-6} (.96*10^{-6})	1.97*10^{-6} (.70*10^{-6})	0.06*10^{-7} (8.28*10^{-7})
	Density 1	-.056 (.048)	.127 (.047)***	.131 (.047)***
	Density 2	.036 (.054)	.073 (.053)	.100 (.053)*
	Density 3	-.0004 (.052)	.042 (.051)	-.004 (.049)
	Density 4	Ref.	Ref.	Ref.
	Density 5	.069 (.055)	.014 (.054)	.038 (.054)
	Density 6	-.025 (.057)	-.0009 (.054)	-.003 (.054)
	Density 7	.025 (.068)	.069 (.068)	.153 (.069)**
	Density 8	-.102 (.054)*	-.153 (.054)***	-.162 (.055)***
	Density 9	.041 (.065)	.104 (.063)*	.024 (.065)
Controls	Occupation Dummy	Yes	Yes	Yes
	Industry Dummy	Yes	Yes	Yes
	Year Dummy	Yes	Yes	Yes
	Region Dummy	Yes	Yes	Yes
	Worker Fixed Effects	Yes	Yes	Yes
	No. Observations	173,614	173,614	173,614
	No. Groups	39,758	39,758	39,758
	Adj. R^2 (overall)	.2534	.2818	.2826

Notes: Regressions are augmented by the familiar full set of determinants of individual productivity, which are not shown here since they display the expected usual properties; standard errors are cluster corrected by regional ShareHQ; 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; *Ref.* indicates reference category for dummy variables.

Table VII – Panel Estimates, Robustness Checks (II)

	Dependent Variable: $\ln(wage_i)$					
		(XV)	(XVI)	(XVII)	(XVIII)	(XIX)
Alternative Measures of Regional Human Capital	Share HQ * HQ	.702 (.057)***	-1.39 (.384)***	-	-	-
	ShareHQˆ2*HQ	-	12.85 (2.76)***	-	-	-
	ShareHQˆ3*HQ	-	-21.72 (6.01)***	-	-	-
	Share HQ*NHQ	-.0007 (.025)	-.277 (.092)***	-	-	-
	ShareHQˆ2*NHQ	-	1.73 (.824)**	-	-	-
	ShareHQˆ3*NHQ	-	-2.10 (2.13)	-	-	-
	AvEducation * D^{HQ}	-	-	.094 (.007)***	-	-
	AvEducation*D^{NHQ}	-	-	-.007 (.003)**	-	-
	Kurtosis*HQ	-	-	-	-.007 (.001)***	-
	Kurtosis*NHQ	-	-	-	.0002 (.0002)	-
	Herfindahl*HQ	-	-	-	-	-.292 (.034)***
	Herfindahl*NHQ	-	-	-	-	-.011 (.013)
Alternative Explanations for Urban Wage Premia	Unemployment Rate * D^{HQ}	-.017 (.001)***	-.016 (.001)***	-.017 (.001)***	-.019 (.001)***	-.018 (.001)***
	Unemployment Rate * D^{NHQ}	-.002 (.0009)***	-.002 (.0009)***	-.002 (.0009)***	-.002 (.0009)***	-.002 (.0009)***
	Land Price Level * D^{HQ}	.004 (.004)	.003 (.004)	-.0004 (.004)	.012 (.004)***	.010 (.004)***
	Land Price Level * D^{NHQ}	-.003 (.001)	-.003 (.002)	-.002 (.002)	-.004 (.002)**	-.003 (.002)**
	Amenities * D^{HQ}	$1.01*10^{-6}$ $(.78*10^{-6})$	$-.23*10^{-6}$ $(.79*10^{-6})$	$-1.06*10^{-6}$ $(.77*10^{-6})$	$1.85*10^{-6}$ $(.77*10^{-6})$**	$1.43*10^{-6}$ $(.77*10^{-6})$*
	Amenities * D^{NHQ}	$1.41*10^{-6}$ $(.71*10^{-6})$	$.40*10^{-6}$ $(.73*10^{-6})$	$1.51*10^{-6}$ $(.71*10^{-6})$**	$1.77*10^{-6}$ $(.71*10^{-6})$**	$1.56*10^{-6}$ $(.71*10^{-6})$**
	Density 1	.262 (.046)***	.254 (.046)***	.259 (.046)***	.038 (.047)	.261 (.047)***
	Density 2	.209 (.052)***	.209 (.052)***	.209 (.052)***	.108 (.053)**	.209 (.053)***
	Density 3	.148 (.049)***	.145 (.049)***	.147 (.049)***	.046 (.049)	.142 (.049)***
	Density 4	Ref.	Ref.	Ref.	Ref.	Ref.
	Density 5	.223 (.053)***	.222 (.053)***	.220 (.053)***	.124 (.055)**	.219 (.054)***
	Density 6	.102 (.054)*	.097 (.054)*	.101 (.054)*	.013 (.057)	.099 (.054)*
	Density 7	.192 (.067)***	.185 (.067)***	.181 (.067)***	.104 (.068)	.204 (.067)***
	Density 8	.014 (.055)	.013 (.055)	.038 (.055)	-.073 (.054)	.021 (.054)
	Density 9	.060 (.058)	.103 (.059)*	.049 (.058)	-.068 (.059)	.044 (.058)
Controls	Determinants of Individual Productivity	Yes	Yes	Yes	Yes	Yes
	Occupation Dummy	Yes	Yes	Yes	Yes	Yes
	Industry Dummy	Yes	Yes	Yes	Yes	Yes
	Year Dummy	Yes	Yes	Yes	Yes	Yes
	Region Dummy	Yes	Yes	Yes	Yes	Yes
	Worker Fixed Effects	Yes	Yes	Yes	Yes	Yes
	No. Observations	173,614	173,614	173,614	173,585	173,614
	No. Groups	39,758	39,758	39,758	39,756	39,758
	Adj. Rˆ2 (overall)	.2833	.2836	.2835	.2829	.2828

Notes: Regressions are augmented by the familiar full set of determinants of individual productivity, which are not shown here since they display the expected usual properties; all standard errors are cluster corrected by regional ShareHQ; 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; *Ref.* indicates reference category for dummy variables.

Table VIII – Panel and IV(Second Stage) - Estimates by Industry

Dependent Variable: ln(wage$_i$); West Germany								
	(XXVI)		(XXVII)		(XXVIII)		(XXIX)	
	Agriculture		Production of Raw Materials		Production of Primary Investment Goods		Production of Secondary Investment Goods	
	Panel	Panel-IV	Panel	Panel-IV	Panel	Panel-IV	Panel	Panel-IV
Share HQ*HQ	.459	3.90	1.22	4.57	.968	3.16	1.28	2.13
	(.45)	(1.2)***	(.23)***	(.64)***	(.221)***	(.63)***	(.21)***	(.68)***
Share HQ*NHQ	-.331	-.309	-.157	.642	-.054	-.112	.055	.267
	(.16)**	(.87)	(.08)**	(.52)	(.08)	(.53)	(.09)	(.62)

	(XXX)		(XXXI)		(XXXII)		(XXXIII)	
	Production of Consumption Goods		Food Production and Processing		Construction, Primary		Construction, Secondary	
	Panel	Panel-IV	Panel	Panel-IV	Panel	Panel-IV	Panel	Panel-IV
Share HQ*HQ	1.05	6.66	.433	4.29	1.97	3.52	.709	3.14
	(.32)***	(.85)***	(.44)	(1.1)***	(.31)***	(.72)***	(.52)	(1.3)**
Share HQ*NHQ	-.151	.619	.085	-1.37	-.106	.515	.187	1.31
	(.07)**	(.52)	(.09)	(.62)**	(.09)	(.59)	(.10)*	(.65)**

	(XXXIV)		(XXXV)		(XXXVI)		(XXXVII)	
	Distribution Services (I)		Distribution Services (II)		Transport and Information Services		Industry Services	
	Panel	Panel-IV	Panel	Panel-IV	Panel	Panel-IV	Panel	Panel-IV
Share HQ*HQ	1.39	2.90	.401	1.48	.781	2.59	1.24	1.78
	(.27)***	(.76)***	(.40)	(.79)*	(.41)*	(.79)***	(.16)***	(.61)***
Share HQ*NHQ	-.173	-.133	-.110	1.02	-.022	.278	-.129	-.142
	(.11)	(.65)	(.09)	(.60)*	(.09)	(.55)	(.10)	(.59)

	(XXXVIII)		(XXXIX)		(XL)		(XLI)	
	Consumer Services		Society Services (I)		Society Services (II)		Social Security	
	Panel	Panel-IV	Panel	Panel-IV	Panel	Panel-IV	Panel	Panel-IV
Share HQ*HQ	1.56	4.03	.854	2.07	.496	1.50	.069	1.28
	(.37)***	(.97)***	(.14)***	(.49)***	(.195)**	(.62)**	(.15)	(.46)***
Share HQ*NHQ	-.077	.852	-.195	-.764	-.287	-.149	.021	-.181
	(.13)	(.84)	(.07)***	(.46)*	(.09)***	(.56)	(.06)	(.38)**

Notes: All regressions are panel regressions on individual gross daily wage, augmented by the familiar full set of individual and regional determinants of productivity as well as by density, occupation, industry, year, region and worker fixed effects, all of which are not shown here since they display the expected usual properties; standard errors are cluster corrected by regional ShareHQ; 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 *Amenities* are divided by 10^{-6}.

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