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Human Capital Externalities: A Sectoral-Regional Application for Spain

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RESUMEN
La existencia de efectos externos ligados al capital humano ha sido rechazada en un conjunto reciente de trabajos, centrados en su mayoría en el caso de los EE.UU. Sin embargo, esos trabajos sólo contemplan la posible existencia de efectos externos dentro de áreas definidas administrativa o políticamente: estados, regiones, o ciudades. Dada la naturaleza de los efectos externos del capital humano, su magnitud y su misma existencia debería depender de la intensidad de la interacción entre individuos. Mediante datos individuales de trabajadores hemos analizado la existencia de efectos externos del capital humano en España dentro de cada industria en cada región, así como en las propias empresas. Los resultados no permiten rechazar la existencia de efectos externos significativos, la mitad de ellos fuera del ámbito de cada empresa particular. Esto sugiere la necesidad de un papel activo del sector público promoviendo la inversión en capital humano.

Palabras clave: capital humano, efectos externos, regiones, sectores.

ABSTRACT
Human capital externalities have been rejected recently in a number of papers, focused mainly on the US experience. However, these papers only contemplate the possibility of aggregate externalities within politically defined boundaries, states or cities. Given the nature of human capital externalities, their size and very existence should depend on the intensity of human interaction. Using microdata on Spanish workers, we have analyzed the existence of human capital externalities within each industry in each region and within establishments. The results show the existence of significant externalities, half of it outside the scope of individual firms, which in turn suggests the need of an active governmental role promoting schooling and human capital accumulation.

Keywords: Human capital, externalities, regions, industries.

JEL classification: D62, I20, J30, R10.

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1. Introduction

The existence of external effects of human capital is an important topic. Human capital spillovers are an important explanatory factor in the new growth theory (Lucas, 1988). Furthermore, they imply that the social return to education is higher than the private return to education and this is a standard reason to ask for public funding in education.

The main problem is that, in order to assess the significance of externalities, we need to take into account the internal effects of human capital. The idea is to control for individual characteristics (individual human capital) and then to see if there exists any wage premium due to the average stock of human capital.

The empirical literature on this topic following that approach begins with Rauch (1993), whose results show the existence of aggregate human capital externalities within the US metropolitan areas. However, more recent papers have obtained the opposite result, finding no evidence of territorial human capital externalities. Winter-Ebmer (1994) for Austria, Ciccone and Peri (2000) for the US cities, Acemoglu and Angrist (2000) and Rudd (2000) for the US states, all reject the hypothesis. Winter-Ebmer (1994) for Austria and Sakellariou (2001) for Guatemala show evidence against the existence of national externalities within industries. On the other hand, Moretti (1999) does find human capital externalities for US cities.

As we can see, empirical evidence is restricted mainly to the US and hardly considers the industrial dimension of the problem. However, the main idea is that individual productivity depends not only on individual human capital, but also on the average level of skills or human capital. In fact we can consider that human capital accumulation is a social activity, involving groups of people in a way that has no counterpart in the accumulation of physical capital. Therefore, we must think in terms of a technology through which the average skill level of a group of people is assumed to

affect the productivity of each individual within the group (or even outside the group). From the point of view of such a technology a national economy, a region or even a city are completely arbitrary units to consider.

The external effects of human capital have to do with the influences people have on the productivity of others. Therefore, the scope of such effect must have to do with the ways various groups of people interact, which may be affected by political boundaries but are certainly an entirely different matter conceptually. There does not exist a single correct answer. Many such effects can be internalized within small groups of people (firms or families) and others (a new mathematical result) can be exogenous even to most countries. However, some group interactions central to individual productivity may well involve groups larger than the immediate family and smaller than mankind. In particular, it seems sensible to have a different kind of interaction depending on whether people work in the same industry or not. We can think that, ceteris paribus, a higher level of human capital in agriculture has hardly any effect on productivity in financial services but that the average level of human capital in financial services does have this effect. We can think also that the closer the interaction the stronger the effect. Therefore it is only natural to think that human capital externalities can be especially important between workers within each firm.

In fact, we can find this idea of both industry and location being important in Marshall (1890). He argued that social interactions among workers in the same industry and location create learning opportunities that enhance productivity.

Nevertheless, most of the existing literature based on microdata has not paid any attention to this wide range of possibilities. Rauch (1993), Moretti (1999) and Ciccone and Peri (2000) only deal with the effect of each city's average human capital on individual wages in that city. Acemoglu and Angrist (2000) and Rudd (2000) analyze only the potential effect of each state's average schooling on individual wages in that same state. Sakellariou (2001) only analyzes the effect of national average human capital within each sector on individual wages in that sector. Winter-Ebmer (1994) analyses

within-industry externalities and regional externalities in Austria but he does not consider within-industry externalities within each region.

The aim of this paper is to analyze the existence of human capital externalities in Spain. This is a relevant case because the Spanish Encuesta de Estructura Salarial allows us to study evidence from a country different from the US. Furthermore, we do this by analyzing the existence of within-industry externalities in each region (taking into account both the industrial and the regional dimension). Finally, the nature of the data also makes it possible to analyze externalities at the establishment level.

The rest of the paper is organized as follows. Section 2 summarizes the literature on human capital externalities. In section 3 we outline the estimation method. Section 4 discusses the data. Section 5 reports the results of our empirical analysis. Section 6 offers a summary and concludes.

2. Human capital externalities

Rauch (1993) is the first attempt to estimate human capital externalities. He uses US individual data from the 1 in 1000 B Public Use Microdata Sample of the 1980 Census of Population, collected for Standard Metropolitan Statistical Areas (SMSA) basis. After controlling for individual education, experience, sex, race and other characteristics he finds that the SMSA average education and the SMSA average experience are both significant in raising individual wages. An additional average year of schooling means an increase of 5.1% in the wage, and an additional year of experience means a 0.46% increase. These estimates can be compared with the rates of return to individual schooling (4.8%) and experience (3.5%). These external effects are somewhat lower when including 4 regional dummies for South, West, North Central and Northeast or proxies for the climate and the coastal status of the SMSAs. Then the educational externalities are close to 3% and the average experience is not significant.

Acemoglu and Angrist (2000) use samples of white men aged 40-49 from the 1960-80 US Censuses. They analyse the existence of externalities within each state. Their idea is that higher incomes might cause more schooling instead of the other way around. Therefore, Rauch's results would be due to the fact that cities with more schooling may also have higher wages for other reasons. In order to deal with this problem they use information about the different state compulsory attendance laws and child labour laws over the period 1920-1960. These instruments affect the schooling in each area but are not affected by future wages and seem to be uncorrelated with omitted factors affecting schooling and future wages. Ordinary Least Squares estimates show a large positive relationship between average schooling and individual wages controlling for individual schooling, individual age and state of residence. The size of the externality is 7%, over and above the private returns. However, instrumental variables estimates are around 1 percent and not significantly different from zero. They conclude that small external returns of 1-3% are possible but that there is little evidence of sizeable external returns to education.

Rudd (2000) examines whether the average level of human capital in a region affects the earnings of an individual residing in that region in a manner external to the individual's own human capital. He uses data for fourteen years (1978-91) of the March Current Population Survey (CPS). According to Rudd, Rauch's results could be due to having used only one cross-section. By using a "panel" of pooled cross sections he can control for region specific fixed-effects. Rudd only considers the case of aggregate externalities within states. As a first step, he estimates state-year dummies running mincerian equations. As individual covariates he uses own years of completed schooling, potential labor experience and its square, sex, race, marital status and fourteen industry indicators. As a second step, he uses those state-year dummies as dependent variables and includes as explanatory variables state fixed-effects and some state-specific characteristics such as density, non-wage income per capita and the unemployment rate. (Other variables such as physical capital per worker or schooling quality are not significant). His results show that, by controlling for time-invariant state fixed effects and a limited list of state characteristics, it is possible to cause the estimated external returns

to education (10.8% with a common own return to schooling coefficient, 16.9% with a region-specific one) to vanish. He concludes that the observed relationship is due to the fact that the average level of education in a state is a good proxy for other truly productive factors.

Moretti (1999) analyses regional externalities using panel data for American cities. He does not analyse externalities within industries. His results show that an increase in the supply of college graduates raises less skilled workers' wages (which could be predicted by a conventional demand and supply model, and workers with different levels of human capital being imperfect substitutes), but also college graduates' wages (this latter being due to human capital externalities). A percentage point increase in college graduates in a metropolitan area raises college graduates' wages by 0.4% in that area. These results are robust to controls for differences in unobserved ability across individuals, different returns to skill across cities, city fixed effects or unobservable city-specific shocks.

Ciccone and Peri (2000) estimate human capital externalities in the US cities between 1970 and 1990. They do not find evidence for significant human capital externalities. This result depends critically on considering workers with different levels of human capital to be imperfect substitutes in production[1]. Differently from Moretti (1999), who considers four different groups of workers, according to their results an increase in average human capital reduces its price.

Winter-Ebmer (1994) offers evidence for Austria using microdata from the Austrian Mikrozensus of 1983. He analyses the possibility of within-sector external effects by estimating industry wage premiums, controlling by individual characteristics, and later estimating the effect of average industrial human capital and other variables on them. His results show significant external returns to schooling of 4%-9%. The precise size depends on the additional industrial covariates (investment-output ratios, union

[1] Actually, they only consider two groups of workers to be imperfect substitutes: those without schooling or experience and the rest. That is because in their empirical approach they maintain a mincerian functional form for human capital based on years of schooling, experience and its square.

density, concentration ratio, etc.) although most of the latter are not significant. The existence of externalities due to experience is more dubious. He also analyses the possibility of regional externalities due to human capital by adding average human capital for 98 Austrian counties to the individual wage regressions. His estimates are around 1.6% and are on the margin of significance, but are not robust to the inclusion of house prices. Therefore, he decides to reject regional external effects although Rauch's results indicate that both wages and rents are positively affected by human capital externalities.

Sakellariou (2001) analyzes externalities within industries using microdata from the 1989 Guatemalan Encuesta Nacional Socio-Demografica. He distinguishes 21 industries by combining the one-digit industry classification with the occupational classification. He uses also a two-step method. Although he claims that the presence of external effects cannot be rejected outright, his results show that neither the industrial average years of schooling nor the industrial average work experience are significant at the standard levels of significance.

3. Econometric framework

Using a data set on earnings of individual workers, we want to separate internal returns to human capital from external returns. In order to do that we use standard mincerian log wage equations (Mincer, 1974). We can test the existence of external returns to human capital by adding the variable average schooling to the standard specification. Therefore, to analyze regional externalities we use wage equations such as:

$$\log w_{ijr} = \mu_j + x_{ijr}\beta + z_r\gamma + \varepsilon_{ijr}$$

where the log of the wage of individual i in sector j in region r depends on individual characteristics x (such as individual schooling, experience, square experience or years of tenure and its square), on industrial characteristics (a set of industrial dummies μ) and on regional characteristics z (regional average schooling, but also regional unemployment, regional physical capital per worker or regional density on activity).

Notice that having only a cross section for one year we cannot include fixed regional effects. Nevertheless, we can do so if we want to analyse the existence of externalities within industries within each region,

$$\log w_{ijr} = \mu_j + \pi_r + x_{ijr}\beta + z_{rs}\gamma + \varepsilon_{ijr}$$

where now the log of the wage of individual i in sector j in region r depends on individual characteristics x, on industrial characteristics (μ) and on regional characteristics z (a set of regional dummies π, regional-industrial average schooling, but also other regional-industrial covariates such as physical capital per worker or density of activity in each industry in each region).

In each case we can analyse human capital externalities by testing the significance of the parameter for average schooling.

4. Data

Data on wages and personal characteristics of Spanish workers are available from the Encuesta de Estructura Salarial 1995. This is a new survey on wages with data for thousands of Spanish employees with information about educational attainment, age, sex, type of contract, years of tenure, industry, region and so on. It is available only for one year. The survey excludes workers in agriculture and public services. In order to avoid problems due to the special behaviour of women and temporary workers, we have restricted our sample to male workers with permanent contracts and working all the year. The total number of workers with those characteristics is 88,917. Schooling is measured in number of years of schooling. We can distinguish 9 different industries: 1) Mining and Quarrying, 2) Manufacturing, 3) Public Utilities, 4) Construction, 5) Trade, 6) Hotels and Restaurants, 7) Transports and Communications, 8) Financial Services and 9) Business Services. We can also distinguish 18 different regions and, therefore, we have 162 different industry-regions. Data on physical capital stock for each industry in each region for that same year are obtained from *El stock de capital en España y su distribución*

territorial (Fundación BBV/Ivie, 1998). Total employment in each industry in each region comes from *Renta Nacional de España y su distribución provincial* (Fundación BBV, 1999). Using data on employment in each sector by province and provincial area we have calculated agglomeration indices for each industry in each region as in Rudd (2000), weighting provincial employment densities taking as weights provinces's shares of regional employment in each sector. Unemployment rates are obtained from the Spanish Labour Force Survey (Encuesta de Población Activa).

Table 1 shows the average characteristics for each industry according to the workers pertaining to our sample. There are great wage differences across industries. For example, in Finance wages are almost twice as high as in Hotels and Restaurants. As we can observe, wages are higher than average in some service industries (Business Services, Finance) and in Public Utilities, and lower in some services (Trade and, especially, Hotels and Restaurants) and in Manufacturing. The coefficient of variation of wages between industries is 0.199. As we can observe, differences in terms of average years of schooling are also important across sectors. However, in this case those differences are less extreme, its coefficient of variation being 0.156.

5. Results

First of all, we analyze the existence of externalities within each region. We want to know if, once we take into account each individual's personal characteristics, the average level of human capital per worker in each region increases individual productivity. The results are shown in table 2. Column 2 shows the results of a typical mincerian equation without including aggregate human capital as an additional explanatory variable. Besides individual years of schooling, other standard variables are included: potential experience (measured as age-years of schooling-6) and its square, years of tenure and its square and a set of industrial dummies.

The results are significant and quite sensible. More experience and more tenure implies a higher wage, although in a decreasing pattern. Furthermore, the private return to

schooling is significant and positive implying an increase of 7.5% with each additional year of schooling. This result is quite similar to the one in Acemoglu and Angrist (2000) for the US. Column 2 corresponds to an amplified wage equation including the average years of schooling in each region as well. The private return to schooling is slightly lower (7.1%) now. More important, the external return to schooling is not only positive and significant, but it is even bigger (15.4%) than the private one. Externalities of a similar size are obtained for the US states when no other state-specific variable is included in an OLS regression. Acemoglu and Angrist (2000) obtain external returns between 12.6% and 16.8% depending on the year. Rudd (2000) estimates external returns of 10.8% (16.9% when allowing region-specific return-to-schooling coefficient). Rauch (1993) obtains an estimate of 5.1% for US cities to be compared with his estimate of 4.8% for the private return to schooling.

These results would indicate that externalities are huge, much bigger than the return to own education and fostering education should be at the top of any government's political agenda. However, as Rudd points out there are other regional characteristics that may be the true source of higher productivity and could themselves be correlated with the region's average education level. If education is a normal consumption good, or if there are imperfections in the capital market, a high-wage region can have a higher education level just because it is a high-wage region. Agglomeration economies might be the source of both high wages and larger proportions of highly educated workers. On the other hand, if more educated people have lower unemployment and unemployment decreases wages, the result could be due to an omitted variable, the regional unemployment rate. Finally, if physical capital per worker and human capital per worker are correlated, our results could indicate simply the positive effect of physical capital.

According to Rudd's results for the US experience, non-farm physical capital per worker is not significant, but non-wage income per capita, the log of an agglomeration index and, sometimes, the unemployment rate turn out to be significant. Particularly, adding the first two variables, and especially the agglomeration index, Rudd's estimate of the external return to schooling drops form 10.8% to 4.8%. Adding the unemployment

rate, which enters with the wrong sign and anyway is not significant when combined with both other variables, tends to raise that estimate. These results seem to confirm Rudd's hypothesis, but only partially because the externalities are still significant and of important size.

In our case (see table 2) we include as region-specific variables the log of non-residential physical capital per worker, the log of an agglomeration index of employment and the log of the unemployment rate. Both physical capital per worker and agglomeration are consistently significant and show the expected sign. The estimate of the external return (estimated coefficient on Hr in table 2) is affected only by the inclusion of the agglomeration index, dropping from 15% to 10%. The other variables do not seem to have any impact on it.

Our results indicate that, as in the US, additonal factors play a role in the observed correlation between earnings and average schooling. Therefore, it would be desirable to control for unobserved time-invariant regional characteristics using fixed effects. According to Rudd's results the external returns vanish by including fixed effects without adding any other state-specific variable[2]. In Acemoglu and Angrist (2000) the inclusion of state fixed effects decreases the estimated external returns from 13%-17% to 6%-7%, still a significant externality and as big as the private returns. When Rauch adds four dummies for the big US Census regions, his estimate of external returns also drops from 5.1% to 3.4%, still significant and not too far from his estimate of private returns (4.8%).

However, we do not have observations for different years and we cannot add a fixed effect for each region. Nevertheless, regional fixed effects are possible even with only a cross-section if we analyse externalities within each industry in each region instead of aggregate externalities within each region. Furthermore, in that case we control not only for any time-invariant regional effect, but for any regional effect in that particular period without assuming its time invariability.

[2] However, when allowing region-specific return-to-schooling coefficients the external returns are still significant although much lower, dropping from 16.9% to 3%-4% depending on the additional state-specific covariates.

As we discussed above, if human capital externalities are the result of people's interaction, we should expect them to exist within a common industry rather than between different sectors. The choice made in previous papers for the US case of analysing only aggregate geographical effects is just an arbitrary choice as pointed out in Lucas (1988).

Acemoglu and Angrist (2000) argue that even after including fixed effects the estimate of external returns can be misleading. Their main point is that higher incomes might cause more schooling instead of vice versa. Their solution is to use as instruments data on compulsory attendance laws and child labour laws in US states between 1920 and 1960. They would have affected future average schooling in each area but their adoption would not have been affected by future wages. After instrumenting, their results show external returns to schooling of around 1% but this estimate is not significantly different from zero. However, their final conclusion is that their results "lead to confidence intervals that include external returns of, say, 1-3%. External returns of this magnitude are sufficient to justify significant subsidies for education".

Notice that higher incomes in a region can induce higher average levels of schooling, but this should be a common regional effect (although it could be a variable one over time) for every industry within each region, and should be captured by the regional dummies. Obviously, Acemoglu and Angrist cannot both use a different set of state fixed effects for each year and estimate human capital externalities, because they only focus on the effect of average state schooling.

Analysing externalities within industries or firms is, therefore, appealing on theoretical and empirical grounds. Table 3 shows the results when allowing for externalities within each industry in each region, adding the average level of schooling for each region-industry to our specification. The estimates of coefficients related to individual characteristics are very similar to the ones obtained previously. Looking at column 2 we can see that the new variable is significant and its coefficient indicates an

external return to average industrial schooling of 5.8%. Although the aggregate regional externalities remain significant its point estimate decreases to 9.6%, very close to the estimate obtained adding state-specific variables. These results could be due to some other omitted variables, namely the stock of physical capital per worker in each industry in each region, or the effect of different degrees of agglomeration in each industry and each region. Column 3 shows the results adding those variables. We can see that both are significant and have the expected positive sign. Moreover, the size of both types of externalities decreases, although both remain significant. Aggregate externalities drop from 9.6% to 5.5% and industrial externalities from 5.8% to 3.9%.

Obviously, this could be due to some other regional factor different from physical capital intensity or agglomeration economies. However, although we cannot test the robustness of aggregate externalities to this problem, we can do it for the industrial externalities. In order to do that we drop the average regional schooling. Column 4 shows the new results including regional effects but not any other region-industry specific variable apart from schooling. The estimated external return is 4.1%, very close to the one obtained without fixed effects. In column 4 we again include the two region-industry specific variables, physical capital intensity and agglomeration. Externalities remain significant at a very similar level of 3.7%.

Therefore, positive externalities related to human capital seem to exist within each industry in each region. Their size is quite important and more sensible than the large initial estimates. Furthermore, it is possible that some degree of externalities exists between different industries within a region. On the other hand, it is possible that within-industry externalities exist between different regions as well. Columns 5 and 6 show the results obtained by adding the national average schooling in each sector. In order to do that we have to drop the industrial dummies, but in column 6 we include region-industry physical capital per worker and agglomeration. These variables should at least control for part of the industrial characteristics. The results are compatible with industrial externalities of about 4% within regions and 1% between regions. Both are significant.

Although tentative, as we have only one cross section, these results show that externalities can exist between different regions. This is logical because the intensity of interactions of every kind should be more important within regions than between regions. Actually, the nature of our data (a wage survey) makes it feasible to analyze an additional dimension for human capital externalities. If the average level of schooling in each region and industry increases an individual's productivity, this should be especially true within each firm. Since we have information about the establishment where each individual works, we can analyse within-firm externalities.

Table 4 shows the results obtained by including the average schooling within each establishment. As we can see, this variable turns out to be significant, its positive coefficient implying an external return of 2.3% within each establishment. The regional within industry externalities (excluding the previous intra-firm effect) remain significant, although their size decreases to 2.3%, the same size as the intra-firm externality. Finally, the return to individual schooling decreases slightly from 7.1% to 6.1%.

Looking at our results we cannot reject the existence of significant human capital externalities within industries. These would be especially important within firms and between firms within regions. Our results for externalities between different industries within a region or between different regions within an industry are more tentative due to the nature of our data. However, everything indicates that, although externalities between regions might exist, their size would be much smaller than within a region or a firm. Actually, our estimates lead to external returns of 2.1%-2.5% within establishments and 1.7%-3% within industries (in the same region). These effects are quite sizeable if we consider that the private return to schooling is around 6%-7% for each additional year of schooling. Part of these externalities, those existing within establishments, could be internalized by firms, but not those existing at the industry level.

Previous papers showed that the initial huge externalities estimated were due to different problems related to the omission of other variables that affect productivity and wages at the regional level or to reverse causality. However, by focusing only on aggregate externalities within a region, they have failed to capture the fact that

externalities are mainly to be found at less aggregated levels. The reason is that human capital externalities are due to people interacting with each other, and this interaction is more intense within firms and within the same industry in each region.

6. Conclusions

The existence of human capital externalities is an important topic. Their existence implies that the social return to education is higher than the private return to education and this is a reason to ask for public funding in education. Recent papers, most of them for the US economy, have rejected the hypothesis of human capital externalities. According to them, the huge externalities observed are only apparent and due to not having taken into account other factors properly. Winter-Ebmer (1994) for Austria, Ciccone and Peri (2000) for the US cities, Acemoglu and Angrist (2000) and Rudd (2000) for the US states, all reject the hypothesis.

Nevertheless, the external effects of human capital have to do with the influences people have on the productivity of others. Therefore, the scope of such effects must be to do with the ways various groups of people interact, which may be affected by political boundaries, but are certainly an entirely different matter conceptually. There is no single correct answer. In particular, it seems sensible to have a different kind of interaction depending on whether people work in the same industry or not. We can think also that the closer the interaction the stronger the effect. Therefore, it is only natural to think that human capital externalities can be especially important between workers within each firm.

Using microdata for the Spanish case, we have analyzed the existence of human capital externalities at different levels: within a region, within an industry, within each industry in each region and finally within each establishment. We have controlled for the effect of different variables: unemployment rate, physical capital per worker, an index of the agglomeration of activity and, finally, unobservable fixed effects at regional and industrial level. The inclusion of control variables reduces the size of the externalities

estimated initially, which agrees with the recent empirical findings in the literature. However, we cannot reject the existence of human capital externalities within the same industry-region nor within establishments. As a result of these externalities the rate of returns to schooling rises from 6-7%, for own schooling, to around 10%.

Therefore, our results do not support the existence of externalities as big as, or bigger than, the private return to schooling, but do support externalities of a more moderate but still quite significant size (3-4%). Part of those externalities, around 2%, exists outside the scope of individual firms. These results imply that there are good reasons to defend an active role of the public sector fostering schooling and the accumulation of human capital in order to take advantage of those externalities.

These results show the need for exploring other possibilities apart from the traditional political or administrative territorial boundaries, in order to capture a phenomenon so complex as that of human capital externalities.

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Table 1. Descriptive Statistics

	Wage (Th. Pesetas)	Age (years)	Experience (years)	Tenure (years)	Schooling (years)	Obs.
Mining	3317.7	42.89	29.40	13.68	7.49	1605
Manufac-turing	3246.4	42.53	28.09	15.11	8.43	49761
Public Utilities	4423.9	44.57	29.00	17.24	9.56	3859
Construc-tion	3391.9	44.38	30.11	14.39	8.27	4703
Trade	3066.8	39.83	24.87	12.66	8.95	6918
Hotels & Restaurants	2539.5	40.78	27.09	12.89	7.69	3129
Transport &Commu-nication	3447.1	43.29	28.25	15.05	9.03	6530
Finance	4886.5	42.31	24.73	17.18	11.6	9072
Business activities	3834.9	39.10	21.99	10.14	11.1	3340
Total	3471.8	42.35	27.42	14.89	8.94	88917

Table 2. Within-region human capital externalities

	0	1	2	3	4	5	6	7	8
Exp	0.0339 (55.67)	0.0338 (56.67)	0.0337 (56.44)	0.0340 (57.16)	0.0338 (56.69)	0.0338 (56.89)	0.0338 (56.45)	0.0340 (57.16)	0.0338 (56.87)
Exp^2	-0.0004 (-40.20)	-0.0004 (-41.41)	-0.0004 (-41.18)	-0.0004 (-41.92)	-0.0004 (-41.44)	-0.0004 (-41.63)	-0.0004 (-41.19)	-0.0004 (-41.92)	-0.0004 (-41.62)
Tenure	0.0126 (22.86)	0.0128 (23.81)	0.0128 (23.79)	0.0128 (23.90)	0.0128 (23.82)	0.0128 (23.88)	0.0128 (23.80)	0.0128 (23.90)	0.0128 (23.88)
$Tenure^2$	-0.0001 (-7.78)	-0.0001 (-9.13)	-0.0001 (-9.22)	-0.0001 (-9.25)	-0.0001 (-9.13)	-0.0001 (-9.41)	-0.0001 (-9.22)	-0.0001 (-9.25)	-0.0001 (-9.41)
Hi	0.0750 (161.31)	0.0712 (156.56)	0.0712 (156.37)	0.0711 (157.04)	0.0712 (156.57)	0.0710 (156.78)	0.0711 (156.37)	0.0711 (157.04)	0.0710 (156.78)
Hr		0.1539 (64.14)	0.1568 (65.46)	0.1027 (31.83)	0.1541 (64.10)	0.1008 (31.23)	0.1569 (65.40)	0.1028 (31.83)	0.1007 (31.55)
Ln k			0.0952 (9.60)			0.1536 (15.26)	0.0942 (9.48)		0.1539 (15.25)
Ln aggind				0.0349 (24.71)		0.0394 (27.35)		0.0348 (24.69)	0.0394 (27.39)
Ln unempl rate					-0.0118 (-2.15)		-0.0085 (-1.53)	-0.0047 (-0.85)	0.0017 (0.32)
Regional dummies	No	No	No	No	No	No	No	No	No
Industrial dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.409	0.437	0.438	0.441	0.437	0.443	0.438	0.441	0.441

Note: OLS estimates. Log of wage is the dependent variable. Heteroscedasticity-consistent t-ratios in brackets. Hi is individual years of schooling, Hr is regional years of schooling, k is physical capital per worker and aggind an agglomeration index of employment.

Table 3. Within-industry human capital externalities

	0	1	2	3	4	5	6
Exp	0.0338	0.0338	0.0339	0.0344	0.0344	0.0353	0.0349
	(56.67)	(56.68)	(57.22)	(58.23)	(58.36)	(59.42)	(59.02)
Exp^2	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004
	(-41.41)	(-41.43)	(-41.94)	(-42.69)	(-42.78)	(-43.51)	(-43.18)
Tenure	0.0128	0.0128	0.0128	0.0126	0.0126	0.0132	0.0130
	(23.81)	(23.78)	(23.93)	(23.70)	(23.74)	(24.55)	(24.34)
$Tenure^2$	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001
	(-9.13)	(-9.20)	(-9.63)	(-9.47)	(-9.61)	(-9.54)	(-9.70)
Hi	0.0712	0.0706	0.0704	0.0707	0.0707	0.0715	0.0712
	(156.56)	(154.49)	(155.25)	(156.32)	(156.53)	(157.59)	(157.12)
Hr	0.1539	0.0962	0.0552				
	(64.14)	(24.26)	(12.76)				
Hsr		0.0581	0.0393	0.0413	0.0365	0.0577	0.0394
		(17.92)	(11.82)	(12.44)	(10.82)	(16.96)	(11.65)
Hs						0.0103	0.0091
						(2.83)	(2.48)
Ln k			0.0887		0.0722		0.0429
			(17.37)		(11.47)		(21.75)
Ln aggind			0.0401		0.0547		-0.0178
			(30.75)		(14.24)		(9.47)
Regional dummies	No	No	No	Yes	Yes	Yes	Yes
Industrial dummies	Yes	Yes	Yes	Yes	Yes	No	No
R^2	0.437	0.439	0.447	0.453	0.455	0.440	0.447

Note: OLS estimates. Log of wage is the dependent variable. Heteroscedasticity-consistent t-ratios in brackets. Hi is individual years of schooling, Hr is regional years of schooling, Hsr is industrial years of schooling in each region, Hs is industrial years of schooling, k is physical capital per worker and aggind an agglomeration index of employment.

Table 4. Within-firm human capital externalities

	(1)	(2)
Exp	0.0343 (58.49)	0.0343 (58.61)
Exp^2	-0.0004 (-42.80)	-0.0004 (-42.88)
Tenure	0.0128 (24.12)	0.0128 (24.16)
$Tenure^2$	-0.0001 (-10.17)	-0.0001 (-10.31)
Hi	0.0612 (112.39)	0.0612 (112.47)
Hsr	0.0279 (8.43)	0.0231 (6.85)
Hest	0.0229 (33.34)	0.0230 (33.38)
Ln k		0.0724 (11.62)
Ln aggind		0.0548 (14.35)
Regional dummies	Yes	Yes
Industrial dummies	Yes	Yes
R^2	0.461	0.462

Note: OLS estimates. Log of wage is the dependent variable. Heteroscedasticity-consistent t-ratios in brackets. Hi is individual years of schooling, Hsr is industrial years of schooling in each region, Hest is years of schooling in each establishment, k is physical capital per worker and aggind an agglomeration index of employment.

Appendix

Dependent variable:

Log of the individual wage

Individual Variables:

Exp: number of potential years of experience (Age-years of schooling-6).

Tenure: number of years of labour experience at the present job.

Hi: number of years of schooling.

Aggregate variables:

Hr: average number of years of schooling in the region where the individual works.

Hsr: average years of schooling in the industry and the region where the individual works.

Hs: average number of years of schooling in the industry where the individual works.

Hest: average number years of schooling in the establishment where the individual works.

k: average stock of non-residential physical capital per worker in the industry and the region where the individual works.

Unemployment rate: unemployment rate in the industry and the region where the individual works.

Aggind: industrial within-region weighted average of provincial employment densities (provincial employment in industry j per km^2) taking as weights the shares of each province in total regional employment in industry j. This is a measure of potential agglomeration economies as in Rudd (2000).

For sources see Data section (section 4).

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