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Human Capital Externalities: Effects for Low-Educated Workers and Low-Skilled Jobs

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Human Capital Externalities: Effects for Low-Educated Workers and Low-Skilled Jobs

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BROERSMA L., EDZES A. J. E. and VAN DIJK J. Human capital externalities: effects for low-educated workers and low-skilled jobs, *Regional Studies*. Investments in human capital are essential themes in many policy programmes. Besides the direct private returns of education, there is evidence of positive human capital externalities at the level of regions and firms. The results in this paper show that both production and consumption externalities have positive effects on wages. Production externalities are transmitted at the level of firms and not at the regional level. For workers in low-skilled jobs, consumption externalities dominate production externalities. Workers on low-skilled jobs earn higher wages when working in cooperation with workers in high-skilled jobs, while for low-educated workers such cooperation with high-educated workers is negative.

Human capital externalities Wage rate Employer–employee matched analysis Multilevel method

BROERSMA L., EDZES A. J. E. and VAN DIJK J. 人力资本外部性：对教育程度较低的工人与低技术工作的影响，*区域研究*。对人力资本进行投资，是诸多政策计划的核心主题。教育除了带来直接的私人回馈之外，亦有证据显示，其在区域及厂商层级具有正面的人力资本外部性。本文的研究结果显示，生产和消费的外部性，皆对薪资具有正面影响。生产外部性在厂商层级进行传播，而不在区域层级传播。对从事低技术工作的劳工而言，消费外部性支配了生产外部性。从事低技术工作的劳工，若与从事高技术工作的劳工合作的话，将会获得更高的薪资，但对教育程度低的劳工而言，与受高等教育的劳工合作的话，影响则是负面的。

人力资本外部性 薪资率 雇主—劳工配对分析 多层级方法

BROERSMA L., EDZES A. J. E. et VAN DIJK J. Les effets externes du capital humain: l'impact sur les travailleurs peu qualifiés et les emplois à faible niveau de compétence, *Regional Studies*. Les investissements dans le capital humain constituent des thèmes essentiels de beaucoup de programmes politiques. Outre le rendement privé direct de l'éducation, il est à constater des effets externes positifs du capital humain au niveau des régions et à l'échelle des entreprises. Dans ce présent article, les résultats montrent que les effets externes dus à la production et à la consommation ont des effets positifs sur les salaires. Les effets externes dus à la production se transmettent à l'échelle des entreprises et non pas au niveau des régions. Pour les travailleurs dans les emplois à faible compétence, les effets externes dus à la consommation dominent les effets externes dus à la production. Les travailleurs dans les emplois à faible compétence sont mieux rémunérés quand ils travaillent en collaboration avec les travailleurs dans les emplois à niveau de compétence élevé, tandis que pour les travailleurs peu qualifiés une telle coopération avec les travailleurs hautement qualifiés s'avère négative.

Effets externes du capital humain Taux des salaires Analyse de données appariées employeur-employé Méthode multiniveaux

BROERSMA L., EDZES A. J. E. und VAN DIJK J. Externalitäten des Humankapitals: Auswirkungen auf Arbeitnehmer mit niedrigerem Bildungsniveau und in gering qualifizierten Stellen, *Regional Studies*. Investitionen in Humankapital sind zentrale Themen in zahlreichen politischen Programmen. Neben den direkten privaten Bildungsrenditen liegen Belege für positive Externalitäten des Humankapitals auf der Ebene von Regionen und Firmen vor. Aus den Ergebnissen dieses Beitrags geht hervor, dass sich die Externalitäten der Produktion und des Verbrauchs beide positiv auf die Löhne auswirken. Externalitäten der Produktion werden nicht auf Regional-, sondern auf Firmenebene übertragen. Für Arbeitnehmer in gering qualifizierten Stellen dominieren Externalitäten des Verbrauchs gegenüber den Externalitäten der Produktion. Arbeitnehmer in gering qualifizierten Stellen verdienen mehr, wenn sie mit Arbeitnehmern in hoch qualifizierten Stellen zusammenarbeiten, während sich eine solche Zusammenarbeit mit höher gebildeten Arbeitnehmern für Arbeitnehmer mit niedrigerem Bildungsniveau negativ auswirkt.

*Corresponding author.

Externalitäten des Humankapitals Lohnhöhe Abgegliche Arbeitgeber-Arbeitnehmer-Analyse Mehrebenen-Methode

BROERSMA L., EDZES A. J. E. y VAN DIJK J. Externalidades del capital humano: efectos en trabajadores con baja formación y en empleos poco cualificados, *Regional Studies*. Los temas principales de muchos programas políticos son las inversiones en capital humano. Además de la directa rentabilidad privada de la formación, existen pruebas de externalidades positivas del capital humano en un ámbito regional y empresarial. Los resultados en este artículo muestran que tanto las externalidades de producción como las de consumo tienen efectos positivos en los salarios. Las externalidades de producción no se transmiten en un ámbito regional sino más bien empresarial. Para los trabajadores en empleos poco cualificados, las externalidades de consumo dominan a las externalidades de producción. Los trabajadores con empleos poco cualificados ganan salarios más altos cuando colaboran con trabajadores con empleos altamente cualificados, mientras que para los trabajadores con baja formación, esta cooperación con trabajadores con alta formación tiene un efecto negativo.

Externalidades del capital humano Tasa de salarios Análisis comparativo entre empleador y empleado Método de varios niveles

JEL classifications: J21, J24, J31, R23

INTRODUCTION

Many Western countries, regions and cities increasingly deal with the issue of how to improve the economic position of their low-skilled and low-educated citizens. The ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD) (2006, p. 24) argues there are three reasons behind this attention. First, many countries and regions experience skill gaps and shortages in specific industries: 'there is a strong pressure to upgrade the skills of low-qualified workers on the domestic market so that they can fill vacancies for more qualified jobs and fuel economic growth'. Second, the desire to increase productivity for many countries, because 'higher productivity improves the position of firms on the global market, attracts inward investment and sustains job creation'. Productivity growth also helps to sustain the current level of welfare, which is important with the rise in ageing in many countries (BROERSMA *et al.*, 2014). Third, there is concern about the 'working poor', a 'vast category of workers in low-paid employment involving harsh working conditions'. This is related to the goal to realize an inclusive labour market in which outsiders (low productive people), who are now unemployed or inactive, can participate and get access to jobs. This is related to the shares of low-educated and low-skilled employment in the economy.

Three themes are addressed in this paper that play a central role in today's discussions about improving the economic position of workers with a low education or of workers in low-skilled jobs. The first concerns the underlying mechanisms that human capital externalities (HCEs) have on employment and wages. In economics, externalities are issues that affect other people who are not part of a specific economic exchange. In the present case, these externalities are related to human capital and how different levels in human capital may influence each other in their joint output level. Economists have long recognized that interactions among workers may help augment human capital that

determines employment, wages, output and, hence, individual productivity. Several previous studies, including ACEMOGLU and ANGRIST (2001), MORETTI (2004a) and LIU (2007), have tested this hypothesis by estimating the effect of city or state average educational attainment on individual earnings. COMBES *et al.* (2012) study the wage and skill distribution by employment density in over 300 French employment areas and find that both more high *and* more low-skilled workers concentrate in dense areas rather than in less dense areas.

HEUERMANN *et al.* (2010) conclude in their literature review that studies of HCEs are still far from reaching a consensus, or, as PSACHARAPOLOUS and PATRINOS (2002, p. 4) mention, 'the results overall are inconclusive'. HCEs are the increases in total earnings resulting from a one-year increase in education (ACEMOGLU and ANGRIST, 2001). Besides the direct private returns for the individual, there is evidence of positive HCEs or positive social rates of return in regions and firms (SCHLITTE, 2012). However, the exact nature of these externalities is unclear. Is it related to only a number of specific occupations of high- or low-skilled workers, as WHEELER (2001), ADAMSON *et al.* (2004) and LEE (2010) show, or to the broader concept of creativity, as argued by FLORIDA (2002) and FLORIDA *et al.* (2012)? Is it related to human capital of *workers*, as argued by LUCAS (1988), or to human capital of *residents*, as argued by SASSEN (2001)? The first type of social return, via workers, will be referred to as production externality; the second type of returns, via residents, will be referred to as consumption externality of human capital. In other words, production externality is defined here as the social rate of return on education of *workers* in a particular area. Workers in such an area benefit from a rise in education of an individual worker, since all can learn from the higher education that this worker has acquired and, hence, they can all improve their output. To distinguish it from this production externality in an adequate way, consumption

(as opposed to production) externality is defined here as the social rate of return on education of *inhabitants* in a particular area.¹ It implies that when the level of education (or skills) of the inhabitants rises, their income is likely to increase and they are themselves thus more likely to hire persons with a lower education or of a lower skill level to perform simple tasks on their behalf, such as cleaning, maintenance and small repairs, gardening, shopping, babysitting, and the like. In fact, this definition is close to what ACEMOGLU (1996) defines as pecuniary externality. This paper provides empirical evidence about the relative importance of these production and consumption externalities of human capital.

The second theme points to today's discussion on whether it is the education of the employee or the skill level of the job that determines economic progress. Education and skill are two different sides of the same medal. Education is a characteristic of a person and, hence, part of labour supply, while required skills are a characteristic of a job and, hence, part of labour demand.² Education and skill are not the same, as is simply illustrated in an increasing research literature on education or skill mismatch (HAMERSMA *et al.*, 2014; OECD, 2011, 2012; DESJARDINS and RUBENSON, 2011; QUINTINI, 2011). The purpose here is to assess whether the effects of HCEs differ when one looks at either education or skill level.

The third and final theme points to discussions about the level at which HCEs influence wages of low-educated employees in general or specifically workers in low-skilled jobs. Is it the regional level or the firm level that matters most as mechanism for transferring HCEs? Moreover, as far as the distribution of different workers or jobs is concerned: Do low-educated workers or workers in low-skilled jobs benefit, in terms of earning higher wages, from the vicinity of many or only a few high-educated workers or workers in high-skilled jobs? This distribution of education or skills within a region or firm is also a subject of the analysis. Basically it gives an indication of the possibility of cooperation between workers of different levels of education or the possibility of cooperation between (workers in) jobs of different levels of skill.

The paper is structured as follows. The second section presents a brief literature review of HCEs. The third section concerns the methodology and data for the Netherlands used in this study. The fourth section presents, discusses and interprets the estimation and test results. Finally, the fifth section concludes.

HUMAN CAPITAL EXTERNALITIES: WHAT MECHANISMS ARE AT WORK?

Without a doubt human capital investments through formal education are an essential theme in many

national, regional and local public policy programmes. It is widely accepted that, at the individual level, more education leads to a better economic position in terms of higher wages and a lower probability of becoming unemployed (HEUERMAN *et al.*, 2010; MORETTI, 2004a, 2004b, 2012). The private internal rate of return to education is around 5–15%, i.e. an additional year of education of a worker leads to a 5–15% increase in his or her wage rate. The existence of high rates of private returns to education provides an incentive for individuals to invest in education. However, the benefits of education may not be solely attributed to the individual, but may spillover to others as well. So the gains to an individual investing in education (the private return) could also raise the returns to the economy as a whole (the social return). This justifies public support for education. The literature on social rates of return to education focuses on the often cited fact that high-educated countries, regions or cities generate more employment and higher labour productivity than low-educated areas, resulting in higher wages for *all* inhabitants of that country, region or city (BERRY and GLAESER, 2005; MORETTI, 2004a, 2004b, 2012; GLAESER *et al.*, 1995).

HCEs reflect production externalities, in the sense that high-educated workers increase the wage rate of other, lower educated, workers. More formally, production externalities raise these wages through a supply effect: extra employment for low-educated workers is created because high-educated workers share knowledge with low-educated ones. Hence, when low-educated workers interact with better-educated ones, they become more productive and creative and, hence, can earn higher wages. There is a longstanding research line that is engaged in investigating these HCEs (see LUCAS, 1988; and overviews in HEUERMAN *et al.*, 2010; PSACHAROPOLOUS *et al.*, 2002; and MORETTI, 2004a, 2004b). At the same time, HCEs may also reflect what are called here consumption externalities, i.e. the spending power of high-educated or high-skilled inhabitants (not necessarily only workers) has a positive effect on the income of inhabitants with a lower education or on a lower skilled job (SASSEN, 2001). SASSEN (2001) argues that this 'consumption externality' of educated individuals is oriented towards services often provided by individuals with a lower education or on a lower skilled job. Consumption externalities raise the income of these low educated through a demand effect: extra employment requiring low skills is created by demand from high-educated individuals. The (wage) income of those low-educated individuals will therefore rise. As a result, production externalities typically occur at the employment location, whereas consumption externalities occur at the residential location.

In addition, one has to determine whether there exists an overlap between the definitions of production and consumption externalities. It is, of course, possible

that a high-educated worker, from whom a fellow (low-educated) worker learns at the working location, will also hire (low-educated) persons at his living location to perform certain tasks in and around the house, such as cleaning, gardening, shopping, babysitting and the like. Of course, when someone lives in the same area where he or she works, that person can be present in both types of externalities. The question then is whether this is a problem of double-counting or not. Both types of externalities are distinguished separately and both have separate definitions, so the overlap of one person being in both types of externalities should not pose a problem as their definitions do not depend on each other. Moreover, even if this were a problem, it still depends on the size of the regions used. The smaller the surface, the larger commuting will be and for commuters there is no problem at all, since they have separate working and living areas to begin with. Of course, now the actual size of the region is important. At the municipality level, commuting is higher than at the (larger) regional NUTS-3 level (Nomenclature des Unités Territoriales Statistiques). Still, commuting in the Netherlands is substantial even at NUTS-3, where about one-third of the workers live in another region. At the municipality level even more than half the workers commute in from other municipalities where they live. The regional demarcation in the third section is based on two-digit zip-code areas in the Netherlands, which amounts to 90 areas, that are somewhere between municipalities ($n = 443$) and NUTS-3 regions ($n = 40$), so commuting will still be substantial and double-counting in production and consumption externalities will not be a problem.

Besides these two forms of externalities, one also has to define what is meant by human capital. The levels of education and skill are intrinsically the two major components of human capital. Education is a characteristic of a person and is related to the qualifications and knowledge acquired through formal education. Skill, on the other hand, is a requirement of a job and is related to competences and expertise, acquired through experience and the training a person needs to possess to fill that job. As is the case with investment in physical capital, investment in human capital will only be undertaken by a wealth-maximizing individual or a profit-maximizing firm, if the expected return to this investment (the so-called net internal rate of return) exceeds the market rate of interest (BLUNDELL *et al.*, 1999).

Another interesting question is whether human capital spillovers transmit between workers and firms. This relates to a large literature on the type of externalities that stimulate agglomeration, innovation and regional growth (for an overview, see DE GROOT *et al.*, 2009) whereby a distinction is made in Porter externalities, i.e. the proximity of workers or firms within the *same* industry, and Jacobs externalities, i.e. spillover effects, as a result of proximity of firms in *different* industries. This paper has yet another approach. It

focuses on the spillover effects on wage rates of individual workers from the distribution of workers with different educational levels in the region, in the work location (firm) and in the residential location.

Three important questions will be addressed here. First, do production and consumption types of externalities exert an effect on the individual wage rate of workers and, if so, which of these two externalities has the strongest effect? How do these externalities affect especially the labour market position of the vulnerable group of low-educated workers or workers in low-skilled jobs? In that sense, do production externalities have an effect on productivity and thus the wage rate and hence income of low-educated workers or of workers in low-skilled jobs? Or do consumption externalities have an effect on the creation of low-skilled jobs and hence the wage rate and income of low-educated workers or workers who fulfil these low-skilled jobs? Second, the paper will investigate the role of HCE at the firm level compared with the regional level on the wage rate of low-educated workers and of workers in low-skilled jobs. The final question is: Does the distribution of low- and high-educated workers or of workers in low- and high-skilled jobs within a firm lead to HCEs?

METHODOLOGY AND DATA

This paper starts from the simple Mincerian framework to assess the impact of educational attainment and a host of individual, firm-level and regional background variables on the individual's wage rate. Its focus is on the effect of contextual factors, such as the education level of co-workers in the same firm and of co-residents in the residential region of the worker, *controlling for* the education level of the individual worker, along with other individual, firm-level and regional characteristics. This implies the following model specification:

$$\log(w_{i,j,k,t}) = \alpha + X_{i,j,k,t}\beta + Y_{j,k,t}\gamma + Z_{k,t}\delta + \varepsilon_{i,j,k,t} \quad (1)$$

$$i = 1, \dots, N, \quad j = 1, \dots, J, \quad k = 1, \dots, K$$

where $w_{i,j,k,t}$ is the vector of the hourly wage rate for the i th individual, working in the j th firm that is located in the k th region at time t . In fact the description of the multi-level model (MLM) in ASLAM and CORRADO (2012) is followed. The intercept α represents the intercept term including fixed effects of industry, firm size and time. Inclusion of these fixed effects implies a model specification as if the variables of equation (1) are all centred with respect to these three items. The explanatory variables in matrix X all relate to each individual employee i who works in firm j , which is situated in region k at time t . Variables that enter X are the individual education

level, individual work experience, gender and so on. Of each individual employee i , the firm j in which he or she works is also known as well as the region in which k each firm j is located. Furthermore, there is information on variables Y that differ at the firm level, but which are similar for each individual employee working within that particular firm. One such variable is firm-level education, which is the average education level of all employees working within that firm. Finally, there is also information about variables Z that differ at the regional level, but which are similar for each employee in each firm that is located within that particular region. Such variables are, for example, the regional worker education level, the regional inhabitant education level and regional unemployment.

Region or firm-level fixed effects are not included because in a repeated cross-section, like the one used, having a large amount of dummies (such as worker, but even firm- or regional-level fixed-effect dummies) means one ends up with degrees of freedom problems. This is because for each year the data are based on different workers in possibly different firms in a different location. Another problem related to adding large amounts of dummies to the model is the fact that these dummies may also capture the effects of actual variables in Y and Z at firm and regional level, respectively, thereby making these variables redundant at the expense of a dummy variable, where the interpretation is much weaker. Finally, β , γ and δ represent vectors of constant parameters.

Equation (1) distinguishes the effects of human capital to the individual wage rate at the individual, firm and regional level. Specification (1) considers a multilevel regression of the wage rate for each i th individual worker, working in the j th firm that is located in the k th region. Even though multilevel data structures also arise in longitudinal studies where an individual's responses over time are correlated with each other, the dataset is not longitudinal. Instead, it can be regarded as a large cross-section with three different levels of aggregation, the individual, firm and regional, hence an MLM. In order to estimate a model with such a complex data structure, the appropriate MLM estimation method is applied.³ MLMs recognize the existence of such data hierarchies by allowing for residual components at each level in the hierarchy. In such cases MLMs yield correct inferences, which standard ordinary least squares (OLS) does not, and they are thus still able to highlight the interest of specific groups (see also SNIJDERS and BERKHOF, 2008).

The dataset used to estimate model (1) is the Working Conditions Survey (WCS) from the Dutch Ministry of Social Affairs. This is an annual employer–employee-matched dataset covering 1995–2006. The WCS is a stratified survey among firms, in which a sample of employees working within each firm is also questioned. Each annual wave of the WCS comprises on average 37 000 employees in about 2000 firms.

The WCS is not a panel in the sense that firms and workers can be followed through time. As mentioned above, it comprises a repeated set of cross-sections of firms and associated workers for each year, i.e. a repeated cross-section. What this in fact means is that over the entire time period covered, the dataset can be seen as one large cross-section of 368 000 employees in 16 000 firms. One variable determines the location of the firm, and thus the work location of the associated employees in terms of a two-digit zip code. These two-digit zip codes divide the Netherlands into 90 areas, around the larger cities. This means that the number of observations N , J and K in equation (1) are $N = 368\,500$, $J = 16\,000$ and $K = 90$.⁴ Since these zip codes refer to the location of the firm, it helps to identify possible production externalities taking place at the work location. Table 1 gives some descriptive statistics of the dataset. Appendix A in the Supplemental data online provides additional information on the data.

The mainstream approach is to evaluate the effects of HCEs on productivity growth in a production function set-up, instead of considering its effect on wages. The wage rate a firm can pay does, however, have a direct link to its productivity. The higher the productivity of a firm, the higher the wage rate this firm can afford to pay its employees. In that sense, productivity and wages are connected. It is always difficult to obtain adequate data that give both firm-level productivity and worker-level variables, such as education or skill. The WCS dataset used does contain the wage rate paid to employees by the firm, but not the productivity of the firm itself which is used to pay this wage. Nevertheless, these two are closely connected, as shown. The sequel just considers the effects of various levels of explanatory variable on the individual wage rate.

Educated and skilled labour

The analysis can relate years of formal education to the individual worker's wage rate in equation (1).⁵ The indicators of HCEs are also based on the years of formal education. Education is therefore the key variable. Effects of education are distinguished in equation (1) at the individual, firm and regional levels. As mentioned above, these different levels imply a multilevel estimation procedure should be applied. The model does distinguish different aggregation levels at which certain variables will be observed. First, for each individual employee, his or her years of education can be obtained from the WCS.⁶ Second, for each firm, the years of education of its employees can be obtained by averaging the years of education of its workers. Third, the years of education in the region (two-digit zip code) in which the firm is located can be obtained in a similar way, i.e. by averaging the number of years of education of each firm located in the region from the WCS. Education at the work location implies a focus on HCEs in terms of production externalities.

Table 1. Descriptive statistics of the Working Conditions Survey (WCS)

	Mean	SD	Minimum	Maximum
<i>Individual characteristics</i>				
Gross hourly wage (€)	12.36	5.88	1.59	87.47
Education (years)	13.74	2.86	8	19
Experience (years)	19.58	11.18	0	52
Female	34%			
Part-time (fewer than 36 hours a week)	13%			
<i>Firm characteristics</i>				
Average education in the firm (years)	13.36	1.95	8	19
<i>Regional characteristics</i>				
Population density (population/km ²)	1127	1194	104	5770
Regional unemployment (share of unemployed in the population aged 15–64 years)	0.054	0.021	0.015	0.144
<i>Human capital externalities (years)</i>				
Average education of the firm work location	13.65	0.76	10.43	16.57
Average education of regional work location, excluding the firm of the worker	13.67	0.78	9.59	16.57
Average education of regional residential location aged 15–64 years	14.65	0.42	13.59	15.85

In order to distinguish between production and consumption externalities, the average years of education of the population aged between 15 and 64 years at their residential location were calculated in each of the 90 two-digit zip-code areas of the Netherlands. These data are from Statistics Netherlands' Labour Force Survey (LFS), which was added to the WCS.⁷ This LFS is surveyed at the residential address and, hence, it measures the average education level at the place of living. This enables one to identify possible consumption externalities at the residential location, in contrast to production externalities that take place at the work location. Note that the number of years of education at the work location from the WCS is slightly lower than that of the LFS at the residential location. This is because certain industries are underrepresented in the WCS, such as public administration and education, which causes a downward bias in the level of education in the WCS compared with the LFS. The LFS is a representative sample. It contains information on the education levels of the total population between 15 and 64 years living in each of the two-digit zip codes in the Netherlands.

In the literature on skills it is common to equate a worker's skill to her or his education level (BACOLOD *et al.*, 2009, 2010). However, education and skill are not the same. Although education is the key variable, this paper does take account of occupational skill levels when interpreting the effect of HCEs on the rates of return on wages. The reason for this is that the group of low educated is not necessarily the same as the group occupying a low-skilled job, because some low-educated workers acquire additional competences allowing them to find a job at a higher skill level than their formal education allows. In such a case, they are under-qualified for the job they fulfil. This paper distinguishes between elementary, low, intermediately, and high and scientifically skilled occupations.⁸

Distribution of workers by education and skill

The more high-educated employees work together with low-educated employees, the more likely it is that information spills over from these high to the low-educated workers. The same holds for the transfer of skills between workers in jobs of different skill levels. This means that low-educated workers or workers in low-skilled jobs may benefit when working next to high-educated workers or workers in high-skilled jobs. The WCS provides information per individual worker on the education level of that worker, as well as on the skill level of the job that this worker fulfils. Therefore, for each firm and each region the distribution of high- and low-educated workers and of workers in high- and low-skilled jobs can be identified.

This distribution is defined as:

$$d = (e_{\text{low}} - e_{\text{high}})$$

where:

$$e_k = \sum_{i \in f} e_{i,k} / e$$

is the share of workers/jobs in firm f by education/skill level k , where k refers to either low- or high-educated workers or to low- or high-skilled jobs. The rationale behind this distribution measure is to assess whether firms specialize in either low- or high-educated workers, or, in terms of jobs, specialize in either low- or high-skilled jobs to achieve productivity growth and hence being able to pay higher wages. This can be exemplified by two well-known company types: is it a MacDonald's type, with many low-skilled jobs (low-educated workers) and just a few high-educated or high-skilled ones; or is it a Microsoft type, with many high-skilled jobs (high-educated workers) and a few low-educated or low-skilled ones, where wages are affected positively. This paper specifically looks at the wages of low-educated workers or workers in

low-skilled jobs. The closer d is to zero, the more evenly workers of different skills or education are spread within a firm. A negative value of d means there are more high-educated workers or workers in high-skilled jobs in the firm than low-educated workers or workers in low-skilled jobs, i.e. a Microsoft-type firm. A positive value of d , on the other hand, means more low-skilled jobs (low-educated workers) than high-skilled (high-educated) ones, so a MacDonald's-type firm.

RESULTS

As a first step, model (1) is estimated to assess the impact of production and consumption externalities of human capital on the wage rate of all workers, irrespective of their levels of education or skill. Next, the production externalities is split into both externalities at the firm level and at the regional level net of the firm. This shows whether production externalities are present at the firm or at the regional level.

Table 2 presents the estimation results when equation (1) was applied to the WCS database for the period 1995–2006 to which information was added about the average education level of the residents aged 15–64 years, at their place of residence. All model specifications in Table 2 include 10-year dummies, implying that (1) is basically estimated as one large cross-section, as the dummies eliminate effects of time. Furthermore, all specifications include 15 industry dummies and eight firm size dummies to account for industry and firm size effects. The typical variables commonly included in these types of Mincerian models, such as experience and experience squared, show the expected sign and significance. The same holds for the finding that female workers have a lower hourly wage rates than average (and thus males). The fact that wages are higher in more densely populated areas and lower in areas with high unemployment is also in line with expectations and with the results found in many other studies. Given the hierarchical multilevel method, the standard goodness-of-fit indicator, R^2 , cannot be calculated, so the value of the likelihood ratio (LR) test relative to a standard linear model has been added. These LR test values of the models in Table 2 can mutually be compared in the sense that the lower the value of the LR test, the better the model fits.

Table 2 comprises five different specifications to identify the effects of HCEs of persons working or living in a region, i.e. a two-digit zip code area, on the individual wage rate. It shows estimated coefficients and associated z -statistics, which have the same function as the usual t -statistics but now follow a standard normal distribution. The second and third columns show the model with solely production externalities. It is assumed that besides the private returns to education for the worker, there is only regional production externality. The results imply that an extra year of

education has a private rate of return of 7.8% on the individual wage. In fact, next to variables reflecting worker properties (like experience, gender and working time), this individual education level has the strongest effect on the individual wage rate in terms of the z -value. On top of this individual education effect, there is also a positive HCE of 0.3% from the average education of workers within the same region, i.e. two-digit zip code. In the third column, this zip-code education effect is split into two parts. Firstly, a firm-level HCE effect, i.e. the level of education that other workers in the same firm have on the individual wage rate. Secondly, a regional HCE effect of the level of education of other workers in the same region (two-digit zip code), excluding the firm. While the second column of Table 2 does show significant regional production externalities to the individual wage, in the third column the regional production externalities are no longer significantly different from zero, but instead the now-included firm-level externalities show up to be highly significant. This indicates that a worker does learn from other workers inside the same firm, but not from those working outside the firm, but in the same region. An extra year of education of workers in the firm will raise the individual wage rate by 0.9% and thus the firm-level production externality is larger than the regional-level production externality of the second column in Table 2. Hence, knowledge transfer takes place on the work floor rather than in the region.

The fourth column of Table 2 shows the results of a model that includes only consumption externalities. An extra year in average education of the inhabitants in a region will raise the individual wage rate in that region by 1.6%. This can be interpreted as an extra demand effect of higher educated inhabitants living in the region consuming more personal low-educated or low-skilled services that leads to the creation of additional jobs. In the fifth column both production and consumption externalities enter the model and it is found that the effect of regional production externalities is significantly smaller than that of regional consumption externalities. Note that the LR test for this model is smaller than that for the second column. This is because of the strong effect that firm-level externalities have on the individual wage rate. The final column presents the estimation results of the model with production externalities, being again split into a firm-level effect and a regional effect, and consumption externalities. The regional production externality net of the firm is, just like the second column, insignificantly different from zero, but the firm-level production externality still has a similar coefficient and still is strongly significant. The regional consumption is slightly lower but is also still significant. These findings of a fairly constant values of firm-level production and regional consumption externality in all model specifications of Table 2 imply that these HCE effects are quite robust. The size of the effect of production externality is slightly

Table 2. Estimation results of equation (1) with maximum likelihood, multilevel mixed-effects model estimation, 1995–2006

Dependent variable	log Hourly wage rate for all employees									
	Coefficient	(z-value)	Coefficient	(z-value)	Coefficient	(z-value)	Coefficient	(z-value)	Coefficient	(z-value)
<i>Individual worker level</i>										
Education level of the individual	0.078	(482.8)	0.077	(451.7)	0.078	(484.1)	0.078	(482.8)	0.077	(451.7)
Experience	0.044	(341.5)	0.044	(341.7)	0.044	(341.5)	0.044	(341.5)	0.044	(341.7)
Experience squared	−7.1E−04	(−242.6)	−7.1E−04	(242.9)	−7.0E−04	(242.6)	−7.0E−04	(−242.6)	−7.1E−04	(−242.8)
Female	−0.068	(−69.3)	−0.068	(−69.9)	−0.068	(−69.3)	−0.068	(−69.3)	−0.068	(−69.9)
Part-time	0.195	(99.1)	0.193	(98.5)	0.195	(99.2)	0.195	(99.1)	0.193	(98.5)
<i>Firm level</i>										
Average education of workers in the firm			0.009	(18.3)					0.009	(18.3)
<i>Regional level</i>										
Average education of workers in the region	0.003	(2.14)					0.003	(2.01)		
Average education of workers in the region excluding the firm			−8.7E−04	(−0.62)					−0.001	(−0.74)
Average education of inhabitants aged 15–64 years in the region					0.016	(2.54)	0.015	(2.39)	0.014	(2.24)
Regional population density	2.1E−05	(6.42)	2.1E−05	(6.48)	1.9E−05	(6.00)	1.8E−05	(5.68)	1.9E−05	(5.75)
Regional unemployment rate	−0.512	(−4.39)	−0.523	(−4.48)	−0.521	(−4.55)	−0.516	(−4.50)	−0.526	(−4.57)
<i>Controls</i>										
Time dummies (10)	Yes		Yes		Yes		Yes		Yes	
Industry dummies (15)	Yes		Yes		Yes		Yes		Yes	
Firm size dummies (8)	Yes		Yes		Yes		Yes		Yes	
Number of variables	38		39		38		39		40	
Number of observations	368 541		368 439		368 541		368 541		368 439	
<i>Goodness of fit</i>										
LR test versus linear regression	65 490		64 514		65 038		65 032		64 057	
<i>Variance components</i>										
Two-digit zip codes	5.7E−04		5.8E−04		4.9E−04		4.8E−04		5.0E−04	
Firm level	0.015		0.015		0.015		0.015		0.014	
All residuals	0.047		0.047		0.047		0.047		0.047	

Notes: *t*-statistics in parentheses are based on clustered standard errors.

The likelihood ratio (LR) test rejects the null hypothesis if the value of this statistic is too small. The LR tests for the various models can be compared, and the smaller LR the better the fit. In that sense, the model of the final column will be the preferred model specification. The variance components refer to each of the three aggregation levels in the multilevel model.

lower than that of the consumption externality. This final model of Table 2 is preferred in terms of the lowest LR test for goodness of fit compared with the LR tests for the other models.

Note that certain coefficient values of Table 2 are extremely small. Therefore, a model based on the same variables net of their mean and a model with standardized variables was also estimated, i.e. net of mean and divided by the standard deviation.⁹ Obviously the coefficient values change, but the associated z -values are very similar to those in Table 2. Therefore, only the estimations of the unadjusted variables of the model specifications are reported in Table 2, even though some may be small. Finally, the variables under the heading of 'variance components' show how large is the share of the total variance of the model at which level of aggregation. It can clearly be concluded that most of the error variance is at the individual level than the firm level, and finally the least at the regional level.

Externalities for employees with low education and employees on elementary and low-skilled jobs

Table 3 shows the results for employees with a low education in the second of third columns and the results for employees on an elementary or low-skilled job in the fourth and fifth columns. The second and fourth columns start with the same specification as the last column of Table 2. These results will first be discussed. Next, the distributions of low- and high-educated workers and of workers in low- and high-skilled jobs are added.

The private returns to education for workers with a low education and for workers in an elementary or low-skilled job in Table 3 are positive and about the same, with a rate of return of about 3.5%. Therefore, an additional year of education for workers with low education or with a low-skilled job will raise their wage rate by about 0.035. Note that this is less than half the return found for all employees regardless of education or skill in Table 2. The coefficients for experience, experience squared, part-time work and population density are largely the same for low educated and low skilled and are also similar to that found in Table 2 for all employees. Next, the differences between the models with all employees and of the low-educated ones or the ones with an elementary or low-skilled job will now be discussed. Starting with the HCEs, interesting differences are found.

The consumption externality of low-educated workers living in the region is about the same as that for all employees, as reported in Table 2, but is only weakly different from zero, while this effect is much larger – and significant – for workers in elementary and low-skilled jobs. In line with the findings, Tables 2 and 3 also show no significant effect of production externality at the regional level net of the firm.

Therefore, it is only at the firm level where an exchange of ideas and help in production between workers takes place and not in the region outside the firm. Furthermore, such production externalities at the firm level turn out to be stronger for low-educated workers than for workers in elementary and low-skilled jobs. Compared with Table 2 for all employees, it can also be seen that the coefficient values for production externality are about twice as large for low-educated workers. For workers in elementary and low-skilled jobs, they are about 50% larger. Therefore, they profit more from a rise in education or skill at the firm level than do all employees.

Table 3 also shows that inclusion of the distribution variable, $d = (e_{\text{low}} - e_{\text{high}})$, has significant but opposite effects in the model of low-educated workers compared with the one of workers in elementary and low-skilled jobs. For low-educated workers a positive coefficient for the distribution d of low minus high-educated employees is found, whereas it is negative for the distribution of elementary and low minus high and scientific jobs. So as far as education of employees is concerned, firms specializing in high-educated workers have $d < 0$, so the wage rate for its low-educated workers – Table 3, third column – will fall. When instead firms have more low-educated workers than high-educated ones, $d > 0$, so the wages for low-educated workers will rise. Notice, however, that at the same time Table 3 shows a remarkable change in the effect of production externalities. This implies that workers inside the firm benefit stronger from a rise in education when d is added. Therefore, for firms with many high-educated workers, this compensates for the lower effect that d has on the wage rate, and likewise, but the other way around, for firms with many low-educated workers.

However, it should be noted that the education level says nothing about the job requirements, which in fact determine the wages being paid by the firm. The current economic crisis lead many high-educated workers to accept jobs of a lower skill level and so earn the lower wages that go with that type of job. It might therefore actually be better to consider the skill level of the job that a worker has rather than his or her level of education. The last two columns of Table 3 show the model for the wage rate of workers in jobs of an elementary and low skill level. The model in the fourth column of Table 3 shows the similar model specification as in the last column of Table 2, but now no longer for all workers, but only for those in elementary and low-skilled jobs. The final column of Table 3 shows that inclusion of the distribution variable of elementary plus low-skilled jobs minus high plus scientifically skilled ones has a negative significant effect. This means that in firms that specialize in high-skilled jobs (i.e. the Microsoft type of firm), the wage rate for their workers in elementary and low-skilled jobs is higher. In other words, workers in

Table 3. Estimation results of equation (1) for employees with a low education and employees on elementary and low-skilled jobs, 1995–2006

Dependent variable	log Hourly wage rate for ...							
	Low-educated employees				Employees on elementary and low-skilled jobs			
Model	Coefficient	(<i>t</i> -value)	Coefficient	(<i>t</i> -value)	Coefficient	(<i>t</i> -value)	Coefficient	(<i>t</i> -value)
<i>Individual worker level</i>								
Education level of the individual	0.035	(82.4)	0.035	(81.2)	0.034	(96.3)	0.035	(97.9)
Experience	0.046	(297.2)	0.046	(297.2)	0.045	(264.2)	0.045	(264.5)
Experience squared	−7.4E−04	(−225.7)	−7.4E−04	(−225.7)	−7.5E−04	(−198.9)	−7.5E−04	(199.2)
Female	−0.051	(−40.6)	−0.050	(−39.6)	−0.014	(−10.1)	−0.013	(−10.0)
Part-time	0.206	(92.6)	0.205	(92.1)	0.176	(76.8)	0.174	(76.0)
<i>Firm level</i>								
Average education of workers in the firm	0.019	(28.7)	0.025	(27.9)	0.013	(17.7)	0.002	(1.62)
<i>Regional level</i>								
Average education of workers in the region excluding firm	−0.001	(−0.79)	−0.001	(−0.86)	−0.003	(−1.61)	−0.003	(−1.67)
Average education of inhabitants aged 15–64 years in the region	0.012	(1.87)	0.012	(1.98)	0.021	(3.48)	0.019	(3.03)
Regional population density	1.4E−05	(4.65)	1.5E−05	(4.93)	1.7E−05	(6.16)	1.6E−05	(5.97)
Regional unemployment rate	−0.377	(−3.17)	−0.392	(−3.26)	−0.509	(−4.10)	−0.470	(−3.77)
<i>Distribution at a firm level of ...</i>								
Low- versus high-educated workers			0.040	(10.7)				
Elementary plus low versus high plus scientifically skilled jobs							−0.073	(−17.4)
<i>Controls</i>								
Time dummies (10)	Yes		Yes		Yes		Yes	
Industry dummies (15)	Yes		Yes		Yes		Yes	
Firm size dummies (8)	Yes		Yes		Yes		Yes	
Number of variables	40		41		40		41	
Number of observations	188 532		188 532		131 773		131 773	
<i>Goodness of fit</i>								
LR test versus linear regression	33 357		33 238		246 992		24 172	
<i>Variance components</i>								
Two-digit zip codes	3.5E−04		3.8E−04		2.4E−04		2.5E−04	
Firm level	0.013		0.013		0.015		0.015	
All residuals	0.034		0.034		0.033		0.033	

Notes: *t*-statistics in parentheses are based on clustered standard errors.

The likelihood ratio (LR) tests for the various models can be compared, and the smaller the LR the better the fit. The variance components refer to each of the three aggregation levels in the multilevel model.

low-skilled jobs benefit from possible learning effects of workers in high-skilled jobs and as a result they earn higher wages. Conversely, when a firm has more workers in elementary and low-skilled jobs than in high and scientifically ones (i.e. the McDonald's type of firm), this will exert a negative effect on the wage rate of elementary and low-skilled jobs. Also note that in this case there is a similar kind of compensatory effect in the firm-level education on the wage of elementary and low-skilled jobs. Whereas the third column of Table 3 shows a positive significant production externality of 1.3%, when d is added in the final column, it fell to a mere 0.2% and is no longer significantly different from zero. Clearly this effect is now in the distribution variable of the final model. For firms that specialize in high-educated workers, this leads to an additional increase in wages of those with low-skilled jobs of 7.3%.

CONCLUSIONS

This paper has investigated three themes that play a central role in today's discussions on how to improve the economic position of low-educated workers or workers in low-skilled jobs. First, the debate on HCEs was unravelled and the question was asked if consumption or production externalities occur and, if so, which of the two has the strongest effects. The results show that an extra year of education has a very strong private rate of return of almost 8% on the individual wage rate. On top of that, employees in general benefit from HCEs, i.e. workers in a firm or region benefit from the average education level in their firm or region. These HCEs can be split in both production and consumption externalities of human capital and both have significant positive effects on the wages of individual employees, but the magnitude of the effect of regional consumption externalities is larger than the production externalities at the firm level.

Second, when one takes a closer look at the production externalities by making a distinction between externalities taking place at the regional or firm level, it becomes clear that production externalities are only transmitted at the level of firms and not at the regional level. Clearly, for learning effects to take place, there needs to be some kind of vicinity on the work floor.

Third, especially for workers in low-skilled jobs, it matters in which type of firm they work in order to benefit from externalities due to the presence of workers with high-skilled jobs. It appears that the distribution of workers in low- and high-skilled jobs within a firm has a negative wage effect for low-skilled workers when a firm has many workers in low-skilled jobs and only a few in high skilled (a MacDonald's type of firm). In contrast, the distribution has a positive wage effect when a firm has many high-skilled jobs and only a few low-skilled ones (a Microsoft type of firm). However,

when instead the education distribution within a firm is added to the model for the low-educated workers, the exact opposite was found. In other words, now a McDonald's type of firm has a positive wage effect instead of the Microsoft type of firm. Note, however, that even though the education of workers and the skill level of jobs will largely coincide, many low-educated workers try to obtain a higher skilled job when they can, but also high-educated workers settle for less when times are bad. So there is a substantial difference between education and skill level.

It is found that a policy strategy with the aim of attracting high-educated workers is beneficial for enhancing the labour market position of low-skilled and low-educated workers. The effect mainly takes place via consumption effects. Therefore, investing in amenities that improve the residential attractiveness is a promising strategy. Stimulating production spillovers via learning effects at the regional level does not work because this mechanism works only at the firm level and is especially effective when workers in low-skilled jobs in firms work together with many high-skilled workers. Therefore, from a learning point of view, aiming at higher productivity and wages of low-skilled workers, attracting a Microsoft type of firms, is preferred to attracting McDonald's type of firms.

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NOTES

1. This definition of consumption externality is not the same as externality through consumption amenities (such as restaurants, theatres and so on). Nor does it refer to gains in individual utility that goes with large or skilled cities. The latter is sometimes referred to technological externality (GLAESER *et al.*, 2001). Instead, the present definition merely serves as a clear (and kind of opposite) distinction from the more usual production externality.
2. This paper ignores the fact that skill can also be seen as a characteristic of a person when it concerns his or her competences to fill a job.
3. Stata version 8 (2013), which allows for the estimation of multilevel models with maximum likelihood estimation, is used. See HOX (1998) for more on multilevel modelling.
4. Not mentioned here is the fact that the actual number of observations on individuals N with which the model is estimated depends on the type of variables that enter the model, but on average amount to 368500.
5. Educational attainment is classified in low, medium and high education. Low educated is defined as those whose highest educational attainment is primary (International

- Standard Classification of Education (ISCED) 0, 1) and secondary education, first stage (ISCED 2). Intermediately educated is those who have attained at least higher and post-secondary education (ISCED 3, 4). High educated is those who have attained at least an education of a tertiary and above level.
6. The definition and calculation of variables is described in Appendix A in the Supplemental data online.
 7. Average education level is available for all 443 municipalities existing in 2007 for the total period 1996–2007 from various issues of the Statistics Netherlands' Labour Force Survey (LFS). This municipal information is next rearranged to the same regional zip code level as the one already used in the WCS.
 8. The skill types in the WCS stem from a specific classification used by the Ministry of Social Affairs, which has been converted here into the Standard Occupational Classification (SOC) of Statistics Netherlands. This SOC distinguishes occupations in elementary, low skilled, intermediately skilled, and high-skilled and scientifically skilled.
 9. These estimation results are available from the authors upon request.

REFERENCES

- ACEMOGLU D. (1996) A microfoundation for social increasing returns in human capital accumulation, *Quarterly Journal of Economics* **111**, 779–804. doi:10.2307/2946672
- ACEMOGLU D. and ANGRIST J. (2001) How large are human–capital externalities? Evidence from compulsory–schooling laws, in BERNANKE B. S. and ROGOFF K. (Eds) *NBER Macroeconomics Annual 2000*, Vol. 15, pp. 9–74. MIT Press, Boston, MA.
- ADAMSON D. W., CLARK D. E. and PARTRIDGE M. D. (2004) Do urban agglomeration effects and household amenities have a skill bias?, *Journal of Regional Science* **44**, 201–224. doi:10.1111/j.0022-4146.2004.00334.x
- ASLAM A. and CORRADO L. (2012) The geography of well-being, *Journal of Economic Geography* **12**, 627–649. doi:10.1093/jeg/lbr041
- BACOLOD M., BLUM B. S. and STRANGE W. C. (2009) Urban interactions: soft skills versus specialization, *Journal of Economic Geography* **9**, 227–262. doi:10.1093/jeg/lbn057
- BACOLOD M., BLUM B. S. and STRANGE W. C. (2010) Elements of skill: traits, intelligences, education, and agglomeration, *Journal of Regional Science* **50**, 245–280. doi:10.1111/j.1467-9787.2009.00650.x
- BERRY C. and GLAESER E. (2005) The divergence of human capital levels across cities, *Papers in Regional Science* **84**, 407–444. doi:10.1111/j.1435-5957.2005.00047.x
- BLUNDELL R., DEARDEN L., MEGHIR C. and SIANESI B. (1999) Human capital investment: the returns from education and training to the individual, the firm and the economy, *Fiscal Studies* **20**, 1–23. doi:10.1111/j.1475-5890.1999.tb00001.x
- BROERSMA L., NOBACK I. and VAN DIJK J. (2014) *Labour Productivity Growth as Panacea for Ageing? – How The Netherlands Can Keep Up its Level of Welfare*. Mimeo. University of Groningen, Groningen.
- COMBES P. P., DURANTON G., GOBILLON L. and ROUX S. (2012) Sorting and local wage and skill distributions in France, *Regional Science and Urban Economics* **42**, 913–930. doi:10.1016/j.regsciurbeco.2012.11.003
- DE GROOT H. L. F., POOT J. and SMIT M. J. (2009) Agglomeration externalities, innovation and regional growth: theoretical perspectives and meta-analysis, in CAPELLO R. and BIJKAMP P. (Eds) *Handbook of Regional Growth and Development Theories*, pp. 256–281. Edward Elgar, Cheltenham.
- DESJARDINS R. and RUBENSON K. (2011) *An Analysis of Skill Mismatch Using Direct Measures of Skills*. Education Working Papers No. 63. Organisation for Economic Co-operation and Development (OECD), Paris.
- FLORIDA R. (2002) *The Rise of the Creative Class*. Basic, New York, NY.
- FLORIDA R., MELLANDER C., STOLARICK K. and ROSS A. (2012) Cities, skills and wages, *Journal of Economic Geography* **12**, 355–377. doi:10.1093/jeg/lbr017
- GLAESER E. L., KOLKO J. and SAIZ A. (2001) Consumer city, *Journal of Economic Geography* **1**, 27–50.
- GLAESER E. L., SCHEINKMAN J. A. and SHLEIFER A. (1995) Economic growth in a cross-section of cities, *Journal of Monetary Economics* **36**, 117–143. doi:10.1016/0304-3932(95)01206-2
- HAMERSMA M., EDZES A. J. E. and VAN DIJK J. (2014) Underqualification as an opportunity for low educated workers, *Environment and Planning C: Government and Policy* **32**. doi:10.1068/c12274r.
- HEUERMAN D., HALFDANARSON B. and SUEDEKUM J. (2010) Human capital externalities and the urban wage premium: two literatures and their interrelations, *Urban Studies* **47**, 749–767. doi:10.1177/0042098009352363
- HOX J. (1998) Multilevel modelling: when and why, in BALARDJAN I., MATHAR R. and SCHADER M. (Eds) *Classification, Data Analysis and Data Highways*, pp. 147–154. Springer, New York, NY.
- LEE S. (2010) Ability sorting and consumer city, *Journal of Labor Economics* **68**, 20–33.
- LIU Z. (2007) The external returns to education: evidence from Chinese cities, *Journal of Urban Economics* **61**, 542–564. doi:10.1016/j.jue.2006.08.007
- LUCAS R. E. (1988) On the mechanisms of economic development, *Journal of Monetary Economics* **22**, 3–42. doi:10.1016/0304-3932(88)90168-7
- MORETTI E. (2004a) Workers' education, spillovers, and productivity: evidence from plant-level production functions, *American Economic Review* **94**, 656–690. doi:10.1257/0002828041464623
- MORETTI E. (2004b) Human capital externalities in cities, in HENDERSON J. V. and THISSE J. F. (Eds) *Handbook of Regional and Urban Economics*, Vol. 4, pp. 2243–2292. Elsevier, New York, NY.
- MORETTI E. (2012) *The New Geography of Jobs*. Houghton Mifflin Harcourt.
- ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD) (2006) *Skills Upgrading: New Policy Perspectives*. OECD, Paris.

- ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD) (2011) *Employment Outlook 2011*. OECD, Paris.
- ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD) (2012) *Better Skills, Better Jobs, Better Lives. A Strategic Approach to Skills Policies*. OECD, Paris.
- PSACHAROPOULOS G. and PATRINOS H. A. (2002) *Returns to Investment in Education: A Further Update*. World Bank Policy Research Working Paper No. 2881. World Bank, Washington, DC.
- QUINTINI G. (2011) *Over-Qualified or Under-Skilled. A Review of Existing Literature*, OECD Social, Employment and Migration Working Papers No. 121. Organisation for Economic Co-operation and Development (OECD), Paris.
- SASSEN S. (2001) *The Global City: New York, London Tokyo*. Princeton University Press, Princeton, NJ.
- SCHLITTE F. (2012) Local human capital, segregation by skill, and skill-specific employment growth, *Papers in Regional Science* **91**, 85–106. doi:10.1111/j.1435-5957.2011.00373.x
- SNIJDER T. A. B. and BERKHOF J. (2008) Diagnostic checks for multilevel models, in DE LEEUW J. and MEIJER E. (Eds) *Handbook of Multilevel Analysis*, pp. 141–175. Springer, New York, NY.
- WHEELER C. H. (2001) Search, sorting, and urban agglomeration, *Journal of Labor Economics* **19**, 880–898. doi:10.1086/322823