Faculty of Economics and Business Administration

A map of human capital in European cities

Research Memorandum 2011-44

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1. Introduction and motivation

"But lo! Men have become the tools of their tools"

(H.D. Thoreau, *Walden*)

Educated men are more productive. The evidence accumulated on this statement is impressive, and ranges from historic records (the Aztech Empire, Japan during the Meji era, Scotland with the 1616 School of Establishment Act) to those of the late nineteenth and twentieth Century.

How much does an additional year of schooling pay off in terms of increased income? This debated question can be tackled from different perspectives; the evidence is, however, quite clear and suggests that private returns to education may be around 8-10 per cent of the resources invested (in terms of both expenditure for obtaining education, as well as foregone earnings), and even larger when considering societies as a whole. However, returns to schooling are not stable over time and space. Support for this statement can be found by inspecting Figure 1, which is obtained as follows. A human capital augmented production function is estimated for EU countries for which the World Bank's World Development Indicators (henceforth, WDI) and Barro-Lee years of schooling data (Barro and Lee 2001) are simultaneously available, over the period 1980-2000, at five-year intervals. We estimated a linear (Cobb-Douglas) production function of the form:

$$y_{i,t} = \beta_0 + \beta_1 * k_{i,t} + \beta_2 * l_{i,t} + \beta_3 * h_{i,t} + \mu_t \quad (1)$$

where lower-case letters indicate log-linearized variables, y, k, l and h measure, respectively, GDP in constant \$2000, the stock of capital,[1] the labour force and human capital (measured on the basis of the years of schooling from the Barro-Lee data set), and, finally, μ_t captures time fixed effects. Estimates have been carried out with the fixed effects estimator, to rule out cycle effects. The β_3 coefficients estimated for each year and education level for the EU27 are plotted in Figure 1.

The empirical results tell an interesting story. Although the estimated coefficients must be treated with caution due to the imperfect measure of schooling and the difficult comparability of data across different countries, this graph shows interesting patterns:

- From all three measures, it can be seen that in Europe, around the mid-1980s, education's pay-offs seemed to have decreased sharply but recovered later. Overall, at the beginning of the new century studying paid off more than 20 years before;
- For European citizens, studying at higher education levels is a rewarding activity; returns to higher education are much higher than returns to basic schooling, which is nowadays taken for granted.

This preliminary evidence suggests, therefore, that studying is indeed a good investment. For private citizens, this translates into higher salaries and better living conditions; and, for cities, regions and countries, in higher growth rates, more healthy populations, and a better standard of living.

An additional side of this story is that human capital does not distribute evenly over space. Responding to incentives, educated people in Least Developed Countries (henceforth, LDCs) tend to migrate to countries where their skills pay higher returns; in rich countries, the educated labour force tends to concentrate in cities, for similar reasons. Not only is human capital unevenly distributed across cities; evidence also suggests – at least in the US, where the phenomenon has been more thoroughly studied – that it is also increasing (Berry and Glaeser 2005).

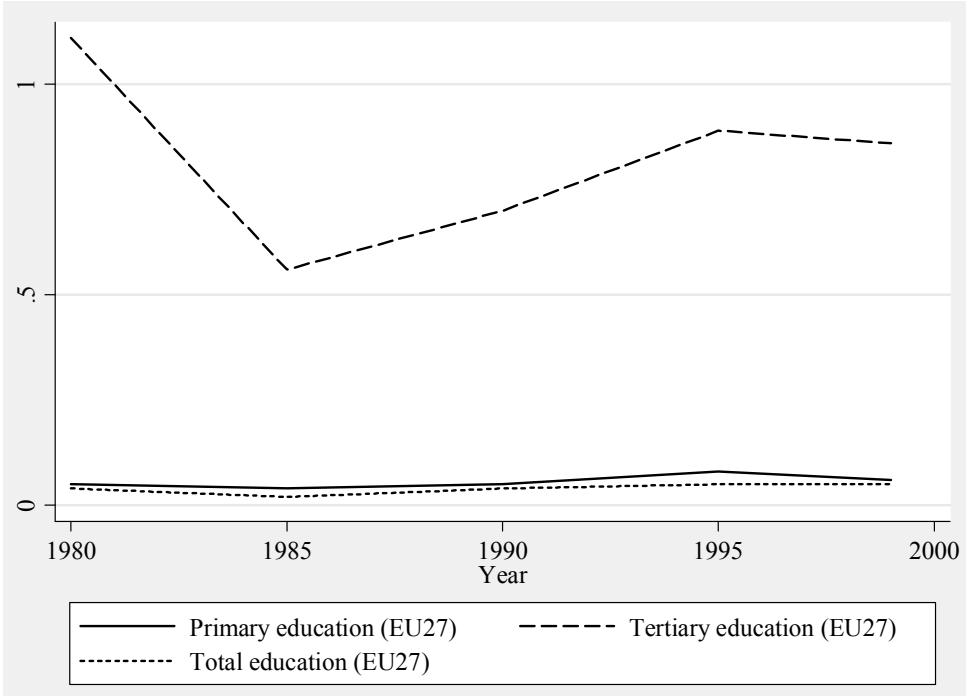

Figure 1 Returns to education by level of schooling in the EU27, 1980-2005
Source: World Development Indicators and Barro-Lee years of schooling, own calculations.

Cities have been historically associated with a concentration of educated labour force (McCormick and Wahba 2005).[2] In urban areas, sectoral diversity increases the creative environment: people and

firms enjoy the mechanism of creative resonance, while by talking to workers of different industries, serendipitous findings can arise. This mechanism was described in Jacobs (1969) and represents a main point of reference for urban economists; furthermore, it is enhanced by the presence of human capital externalities.

In fact, an increase in the urban stock of human capital can benefit cities to an extent that goes beyond the private return to education (Moretti 2004). Human capital is expected to generate positive spillovers at a societal level, through, among others, the following channels:

- It determines gains in productivity both by making individuals more productive, and by making their interactions more fruitful (Lucas 1988);
- It contributes to lowering crime rates (Lochner 2004);
- It can improve the political consciousness of voters (Nie et al. 1996);
- It can trigger the accumulation of social capital (Coleman 1988).

The effects of the concentration of human capital in cities, and, in particular, in European urban areas, are therefore multifaceted and will likely have a profound impact on the future development path of the EU. The significant relevance of this topic notwithstanding, the literature traditionally only offers a variety of studies on the topic of returns of education, ranging from micro-surveys to aggregate cross-country level studies. However, only a few of these thus far tackled the issue of identifying the "hot spots" of human capital in European cities, and how these are changing.[3] Knowing exactly which European cities are richer in human capital, and where the skilled labour force is moving is crucial for improving our understanding of the topic, as well as for shaping sound policies.

This paper aims to fill this gap in our knowledge. We have built a comprehensive data set merging three major sources of information: the EUROSTAT Urban Audit (UA) data set, the European Values Study (henceforth, EVS) 1990 and 2000 waves, and two Globalization and World Cities (henceforth, GaWC) projects. In this way, we are able to capture three major definitions of human capital:

- Formal education (human capital in the form of schooling and formal training, making people more productive);
- Sectoral composition (cities with a high stock of human capital also display relevant concentrations of the labour force in skill-intensive industries);

- Creativity and tolerance (cities with a high stock of human capital are also characterized by having a large share of their labour force in creative sectors, and tend to display a tolerant attitude towards racial diversity, non-standard sexual orientation, culturally diverse immigration, etc.).

Complementary to these three notions of human capital, this paper explores the concept of the functional urban hierarchy. As cities enjoy the presence of power centres, their influence is believed to be wider, the more power centres cities have. More details on each of these four notions of human capital and a critical review of their use in previous studies are given in Section 2.

The reasons for studying these phenomena lie in the tremendous importance of an educated and creative labour force, the existence of advanced, human capital-rich industries, and a network of internationally-connected power centres for European cities. A rich literature in the past few decades has identified human capital as a major source of urban development. Indeed, cities seem to be the focal point of creative learning (as suggested in the seminal Lucas 1988 paper).

This chapter is structured as follows. In Section 2 we review some highlights of the literature on human capital, which lead to the identification of a relative absence of a commonly held framework. In Section 3, we critically review the measures traditionally used to gauge human capital. Section 4 describes the data set used for our empirical analyses. In Section 5, we represent and interpret the spatial and temporal distribution of human capital across European cities. Section 6 concludes, and derives some relevant policy implications along with possible directions for future research.

2. Human capital and cities

Cities are deemed to be the places where physical proximity enhances face-to-face contacts, and determines the emergence of urbanization economies. From a different perspective, the exchange of tacit knowledge may also be fostered in urban environments (Marshall 1920); in turn, speaking a common language, obeying a similar, tacit, set of rules may allow urban dwellers to mutually exchange information and knowledge that induces the process of creative resonance that is at the root of Jacobs (1969). Such Marshallian-Jacobian urban externalities have been subject to thorough theoretical investigation (for a comprehensive survey, see Duranton and Puga 2004), insightful modelling (Glaeser 1999), and careful empirical validation (Glaeser et al. 1992; Henderson et al. 1995).

Urban and regional approaches to this issue have also added to our understanding of urban knowledge externalities. Intuition come from such schools as the *milieu innovateur* theory (Aydalot

1986), which point to urban areas as the most suitable places for knowledge and innovative activity, and identify in urban human capital and knowledge a major driver of urban economic performance.

The idea that human capital is a crucial asset for cities is easily verifiable: it suffices to calculate the set of correlation indices between our measures of human capital and any major indicator of urban performance. This is done in Table 1 below, where all human capital variables are measured in 2001, while GDP is measured in 2004, in order to avoid simultaneity bias. Table 1 shows that indeed correlations are not only mostly positive but also tend to be significant and display remarkable coefficients. Pearson's indices, in fact, reach values as high as 0.75, significant at the 99 per cent confidence level. The four dimensions of human capital we have considered are, in most cases, correlated with each other, as shown in Table 1, corroborating our premise that they are capturing related phenomena. However, some exceptions and qualifications are in order.

Table 1: Correlations between human capital indicators and urban GDP

	Per capita GDP (2004)	**Per capita global firms**	**Global networks**	**Years of schooling**	**High Education Workers**	**Empl. in the high-skills industries**	**Tolerance of homosexuality**
Per capita GDP (2004)	1						
Per capita global firms	0.60*** *(0.00)*	1					
Global networks	0.44** *(0.01)*	0.26** *(0.03)*	1				
Years of schooling	-0.09 *(0.38)*	0.09 *(0.45)*	0.07 *(0.54)*	1			
High Education Workers	0.47*** *(0.99)*	0.22 *(0.15)*	0.32** *(0.03)*	-0.05 *(0.51)*	1		
Empl. in high-skills industries	0.58*** *(0.00)*	0.37*** *(0.00)*	0.24* *(0.06)*	-0.17 *(0.03)*	0.61*** *(0.00)*	1	
Tolerance towards homosexuality	0.65*** *(0.00)*	0.22* *(0.09)*	0.10 *(0.45)*	0.13 *(0.11)*	0.30*** *(0.00)*	0.40*** *(0.00)*	1

Note: p-values in parentheses.

The traditional human capital measure that has been widely used in the economic growth literature, i.e. average years of schooling, is generally unrelated, in statistical terms, to the other measures, and, notably, to GDP. On the other hand, a more production-oriented definition, the percentage of the labour force with higher education is significantly correlated with economic performance and all other human capital dimensions, especially with employment in the high-skills industries (correlation of 0.61, significant at the 1 per cent level) and creative industries (correlation of 0.59, significant at the 1 per cent level, not shown in Table 1), the presence of urban global networks (correlation of 0.32, significant at the 5 per cent level); and a tolerance indicator (correlation of 0.30, significant at the 1 per cent level).

Therefore, given the correlation results presented in Table 1, the standard human capital measure appears to be a rather weak indicator, while a more production-oriented definition seems to be more

related to the other dimensions and economic performance. This result suggests that focusing solely on cumulated years of schooling may be misleading, for two parallel reasons. First, the quality of formal education may be very heterogeneous in different countries, and the total years of schooling may be a poor proxy for the actual human capital levels. Second, human capital can be an endogenous engine for growth only to the extent that it is put to use, i.e. it is productive. In this sense, it is the education level of the workforce that matters most, and the indicator that measures highly educated labour force, accurately captures this aspect.

Workers employed in the high-skills industries are positively correlated with GDP (correlation of 0.58, significant at the 1 per cent level), and are also linked to the other dimensions of human capital. Employment in the creative industries, while not directly correlated with GDP in statistical terms, is significantly linked to employment in the high-skill sectors, tolerance, and the overall workforce with higher education.

The sectoral composition of the labour force seems particularly important, and the high-skills sectors appear as important indicators of urban human capital endowment. Having a significant percentage of employment in high-skills sectors appears to be positively linked to urban economic well-being and correlated to other aspects of the multifaceted human capital endowment of European cities. The conclusion we can draw here highlights the importance of a city's productive and sectoral specialization, and the link between human capital and the high-skills and creative sectors.

Urban knowledge capital and the functional hierarchy of cities, proxied by the presence of global firms and global networks, are clearly positively and significantly correlated with urban GDP (correlation of 0.59 and 0.43, respectively, both significant at the 1 per cent level), and are also linked to the sectoral dimension of human capital and with our tolerance index. Tolerance is also positively correlated with economic performance (correlation of 0.64 with urban GDP, significant at the 1 per cent level), and is linked to the percentage of the highly-educated workforce, employment in the high-skills sectors, and the presence of global networks, indicating that this is yet another possible dimension of human capital.

Thus, urban knowledge capital and the functional hierarchy of cities are relevant dimensions of human capital, and signal the importance for European cities of positioning themselves as global actors in an increasingly interconnected world and economy.

These considerations demonstrate the importance of moving from formal education as the only indicator considered, in the political debate on measures and reforms aimed at increasing human capital levels and endowment as growth enhancing mechanisms.

In the remaining part of the paper, the relationship between human capital and economic performance is taken for granted.[4] We offer a critical description of spatial and temporal patterns in the endowment of human capital in European cities. The aim is to provide both academics as well as practitioners with a toolbox in order to form educated expectations about future development patterns in European cities.

3. How is human capital traditionally being measured?

Since the inception of the concept of human capital at the end of the 1950s (Becker 1964; Mincer 1974), a wide range of indicators have been chosen to capture this elusive concept. In principle, however,

"*The human capital approach considers how the productivity of people in market and non-market situations is changed by investments in education, skills, and knowledge*" (Becker 1992).

The way human capital was initially conceived of was therefore based on an education-driven perspective. People would increase their skills, and therefore would determine an outward shift of the production possibility frontier. This view reflected the wide differences in schooling performance back in the 1950s. In those years, on average, rich countries displayed a schooling performance that was about six times better than lagging countries.[5] However, this gap progressively decreased over time, because of a faster performance in terms of schooling in lagging areas. As recently as 2000, advanced countries had on average just three times as much schooling as countries in South Asia, which were – at that time – the countries with the poorest performance.

Data show that indeed over about 50 years the gap between the best and worst performers in terms of schooling achievement was narrowed significantly. This is mainly due to the convergence process involving those countries that in the 1950s showed the worst performance. Overall, most countries increased their levels of schooling. However, lagging countries did this more so. As a result, differences in relative terms between countries are nowadays less pronounced than 50 years ago: schooling is, therefore, no longer sufficient to capture the essence of human capital.

More recently, an alternative view of human capital posits that schooling is not a sufficient explanation of the wide cross-country income differentials that still affect the world economy. Some critiques stress that pure measures of years of schooling and formal education would only be poor indicators of human capital: in fact, they would ignore the decreasing returns nature of the individual and aggregate stock of human capital, and would not take into account the different quality levels associated with different levels of education achieved in different contexts/countries (Wößmann 2003). Alternative views posit that the sectoral composition of national, regional and urban economies may offer a more insightful explanation of such disparities. This assumption is at

the basis of, among others, the work by Vandenbussche and his coauthors (Vandenbussche et al. 2006). A theoretical model is first employed to show that skilled labour has a higher growth-enhancing effect closer to the technological frontier;[6] next, the model's main insights are verified with panel estimates on 19 OECD countries between 1960 and 2000.

The idea behind this approach is that primary and secondary schooling (i.e., education captured in international statistics with average years of schooling between 3 and 9 years) is nowadays satisfied even in LDCs, and is therefore not sufficient to properly account for cross-country human capital differentials. Different sectoral compositions of regional and national economies may determine the extent to which formal education proves effective, and the degree to which productivity gains are actually determined by an increase in schooling. In other words, economies with a higher concentration of economic activities in skill-intensive sectors may on the one hand require and absorb more skilled labour force, and, on the other, provide an additional boost to economic performance, thus magnifying the positive effects induced by an accumulation of human capital.

Finally, an even more recent development, linked to the concentration of creative professionals in US cities in the first half of the 2000s, envisages the presence of workers in creative professions as a major source of economic growth. This view has found its most visible supporter in Richard Florida. In Florida (2002) he lists numerous examples of US urban areas thriving on tolerance, concentration of painters and musicians, and cultural diversity. Although far from being exempt from critiques[7], this view enhances our understanding of the influence of human capital on urban economic performance. Therefore, this paper analyses creativity-related issues with similar attention to that paid to more traditional human capital indicators.

Cutting across these three dimensions, and in a way complementary to the three of them, is the notion of the functional urban hierarchy (Davoudi 2003). According to this literature, cities would enjoy the presence of power centres within their boundaries. The influence of urban areas would be wider, the more power centres there were in the city. Besides, more power centres would also imply more connectivity to other power centres around the world, in a never-ending chain of connectivity that would eventually identify a proper functional hierarchy of urban centres.

Such a hierarchy would be based on the availability of control centres, including power and control functions, headquarters of multinational companies, relevant branches (for instance, R&D or management and design facilities) of consultancy and finance companies, and diplomatic missions. All these functions would embed human capital-rich activities that would again generate the virtuous circle encompassing higher demand for skilled labour on the one hand, and higher

economic performance on the other. This paper captures this dimension with the data collected by the GaWC research group.

4. The data set

In this paper we make use of data from three main sources: the Urban Audit (UA-EUROSTAT) data, the European Values Study (EVS), and Globalization and World Cities (GaWC) data.

The Urban Audit data set[8] is the result of an ongoing a data collection effort at the European urban level and is provided by EUROSTAT. The aim of this project, which started in 2003, is to collect comparable statistics and approximately 250 indicators for 253 cities in the EU27. All national capital cities are included, along with a sample of large and medium-size cities, covering approximately 20% of the national population in each country. To ensure comparability and a representative sample at the EU-level, selected cities are geographically dispersed in each country, and to guarantee that large and medium-sized cities are equally represented in the data set, in some of the larger countries not all large cities could be included. For the purpose of our research, in order to analyze human capital endowment in European cities, we focus on the 2001 and 2004 waves, and use data on formal education (proportion of working age population qualified at ISCED levels 5-6),[9] and on the sectoral composition of the labour force (proportion of employment in selected industries).

Our second source of data is the European Value Survey (EVS), waves 1990 and 2000. As stated on the official website (www.europeanvaluesstudy.eu) "*the European Values Study is a large-scale, cross-national, and longitudinal survey research program on basic human values*". Data is collected through national surveys of EU citizens, providing information on "*how Europeans think about life, family, work, religion, politics and society*", along with individual demographic, economic, education and employment anonymized data. For most of the individuals, locational information is provided at the urban level, allowing us to compute a city average for each variable of interest. As indicators and proxies of human capital, we have collected data on three main variables: average years of schooling; self reported years of schooling (on a scale of 1-8) from the 2000 wave; and tolerance towards homosexuality from the 1990 wave. For identifying the cities of interest, in the absence of a proper urban identification, we combined two pieces of information available in the data set, viz. the identification of the NUTS region and the size of the city where the interview was conducted.

The final source of information, based on the functional hierarchy dimension of urban human capital, are the data sets compiled by the GaWC group, whose research focuses on external relations of world cities. Coverage is worldwide, and we have selected information on European cities only.

Specifically, we have used information on the number of offices of global service firms in each city and on the number of connections based on global service firms in each city in 2000 (data sets 11[10] and 12[11] of the GaWC).

The combination of these three sources of data resulted in a combined and unique data set that encompasses the three dimensions, described in Sections 1 and 2, with which we identify, measure and map urban human capital endowment in the EU.

5. Empirical analyses

5.1 Introduction

As pointed out in Section 2, human capital has been initially defined as the stock of education capital which is expected to raise workers' productivity. In a world of perfect competition, in the long run capital and labour should be allocated over space so that marginal products are equalized. This should, in principle, also be true for skilled labour: educated workers should flow where their skills have a higher pay-off, so that in the long run the educated labour force should– theoretically – be equally spread over space, in a sort of dartboard approach. But does this actually happen? This section aims to answer this question. Each map represents different definitions of the concept of human capital, as described in Section 2. Given the composite nature of the data employed in the present paper (see Section 4), data coverage varies not only across different data sets but also between each indicator employed. Therefore, the number of observations also displays consistent variation across the maps represented.

Whenever possible, Exploratory Spatial Data Analysis (henceforth, ESDA) is employed to assess the degree to which the spatial distribution of human capital displays autocorrelation and the possible clustering of observations in space; this step is necessary to empirically verify the prediction of the formal a-spatial neoclassical model. To this aim we computed the three most used measures of global spatial autocorrelation:

1. The global Moran's *I*, which is calculated as $I = \left(\frac{N}{\sum_i \sum_j w_{ij}} \right) \left(\frac{\sum_i \sum_j w_{ij} \left(x_i - \bar{x} \right) \left(x_j - \bar{x} \right)}{\sum_i \left(x_i - \bar{x} \right)^2} \right)$;
2. The global Geary's *c*, which is calculated as $c = \left(\frac{\left(N - 1 \right)}{2 \sum_i \sum_j w_{ij}} \right) \left(\frac{\sum_i \sum_j w_{ij} \left(x_i - x_j \right)^2}{\sum_i \left(x_i - \bar{x} \right)^2} \right)$;
3. The global Getis and Ord *G* index, which is calculated as $G\left(d \right) \frac{\sum_i \sum_j w_{ij} \left(d \right) x_i x_j}{\sum_i \sum_j x_i x_j}$.

In the previous equations, x indicates observations of the indicator of interest; a bar over the variable indicates the average value; sub-indices i and j correspond to different locations; w is a generic spatial weight, i.e. an entry of the spatial weight matrix W; and d represents the measure of distance. In the following analyses we employ a contiguity-based distance matrix, with the order of contiguity defined so that each and every observation (city) has at least one neighbour. As each indicator is computed on a different number of observations, this threshold distance varies accordingly.

Both Moran's I as well as Geary's c[12] measure the level of spatial autocorrelation in the data. Moran's I ranges from -1 to +1, the former indicating perfect negative autocorrelation, the latter indicating the opposite case; Geary's c ranges from 0 to 2, with 1 indicating no spatial autocorrelation. Higher positive autocorrelation implies values of c closer to zero. The two indicators are not equivalent, since c is more sensitive to $|x_i - x_j|$, while I is more sensitive to extreme values.

Getis and Ord's G index[13] captures a different dimension of spatial processes: namely, the prevalence, within spatially autocorrelated data, of clusters of high observations surrounded by high observations, or low observations surrounded by low observations. The higher the positive value of the standardized G statistic, the stronger the prevalence of clusters of high observations.

5.2 Formal education

The literature on human capital identifies formal education, on-the-job training, and life-long learning as fundamental sources of productivity improvement for workers. In principle, the educated labour force should be attracted, by higher wages, better living conditions, urban amenities, or a combination of these three causes, to cities where its marginal product is higher. From a production function perspective, this would imply huge flows of skilled workers to cities where capital is relatively more abundant than labour, and in particular where skills pay off more on the job market. However, in the long run, marginal products should be equalized across space and the spatial distribution of the educated labour force should be sparsely scattered over the EU urban space.

Figure 2 maps the spatial distribution of the skilled labour force (defined as the labour force with some or all college education) in EU cities. The textbook portrait given above is not true. The situation (as represented here, viz. as an average of 2001 and 2004 data) is far from representing an equilibrium, especially from the point of view of EU policies which aim at an even distribution of economic potential.[14] Eastern European countries, once rich with graduates from the Communist

era, are nowadays relatively short of skilled labour.[15] Cities where at least 20 per cent of the labour force have a degree or some college education tend to concentrate in Nordic (Sweden and Netherlands) and in large (France, Germany and UK) EU countries. Even within countries, the distribution of the most educated labour force presents disparities, with larger cities – in a hierarchical perspective (à la Lösch 1940) being the places where higher rank functions concentrate, which in turn increases the demand for a skilled labour force. However, the situation does not seem to have come a long way, as the peripheral regions of the former EU15 (i.e., the set of countries that formed the EU before the 2004 and 2007 enlargement rounds) still have lower shares of educated labour force than the central ones. This is particularly true for cities in Spain, Italy and (Northern) Ireland.

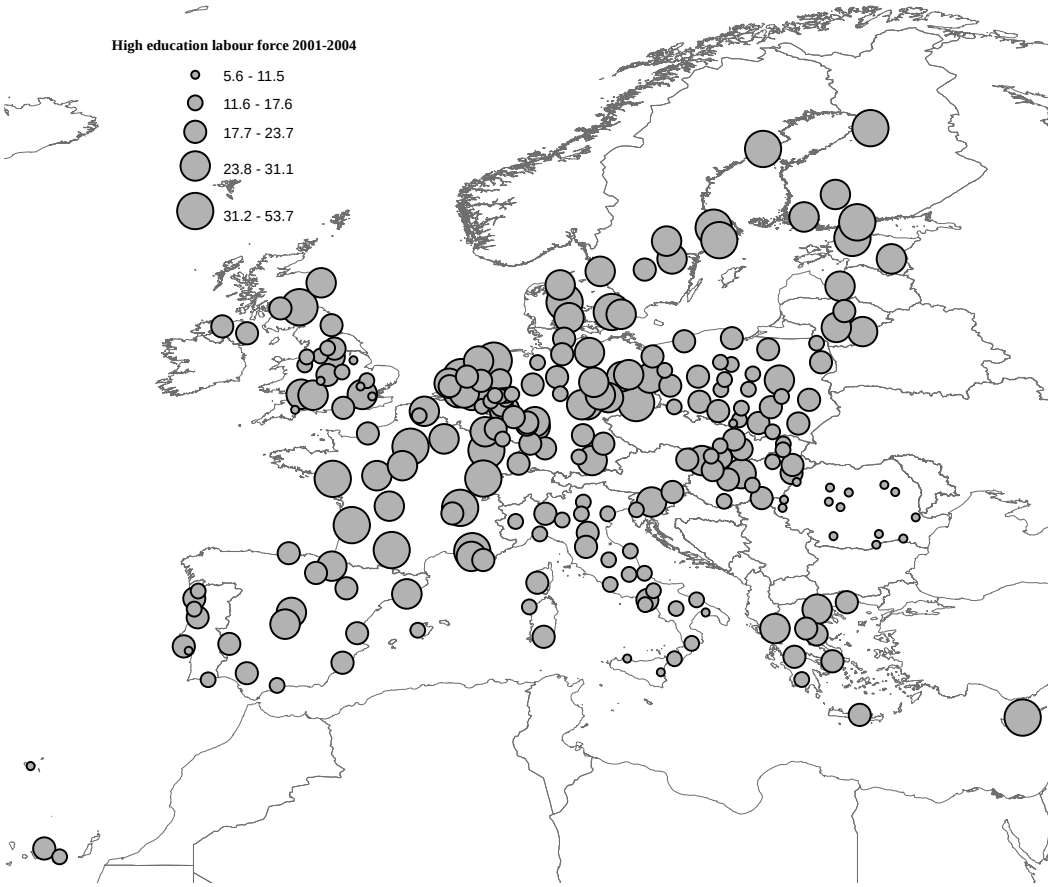

Figure 2: Percentage of labour force with higher (ISCED 5-6) education (average 2001-2004 value)
Source: EUROSTAT (Urban Audit), authors' elaboration.

In the case of this indicator, both Moran's *I* and Geary's *c* provide evidence of positive spatial autocorrelation (the first equals 0.11, the second 0.83; and both are significant at the 1 per cent level). On the other hand, Getis and Ord's *G* is not statistically significant, therefore suggesting no specific spatial clustering pattern in the data.

The spatial distribution of the educated labour force within countries can be further assessed with our data. We merged the percentage of labour force with ISCED 5 and 6 education in the cities surveyed in the Urban Audit project with the same measure calculated for the country as a whole. The ratio of the two indicators represents a location quotient: in other words, the higher the value, the more concentrated in cities the skilled labour force is (with respect to each country of reference). The indicator is built as follows:

$$H_{CtC} = \frac{HELF_{i,j}}{HELF_j} - 1, \tag{2}$$

where H_{CtC} indicates that this specific Human Capital indicator refers to the ratio City to Country; *HELF* stands for High Education Labour Force; subscripts *i* and *j* indicate, respectively, cities and countries of reference. This indicator averaged for the years 2001-2004 is mapped in Figure 3.

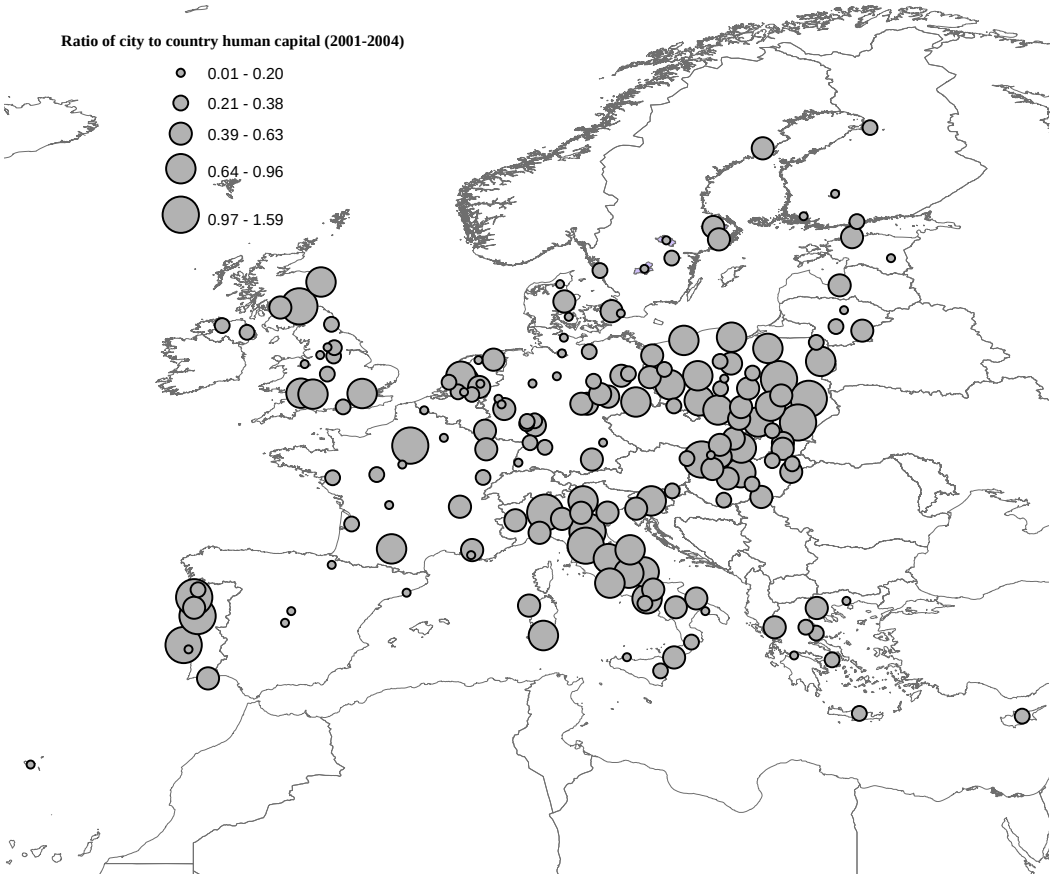

Figure 3: Concentration of human capital in cities 2001-2004
Source: EUROSTAT (Urban Audit), authors' elaboration.

***Note**: Percentage of labour force with higher (ISCED 5-6) education in cities divided by the percentage of the labour force with higher (ISCED 5-6) education in the country -1 (See Equation. 2).*

The results show that, in the EU27, cities have a more educated labour force than the rest of the country of reference; on average, this difference is equal to 31 per cent. However, this indicator

correlates far from perfectly with the pure spatial distribution of human capital in cities (Pearson's correlation index between the indicators mapped in Figures 4 and 5 equals 0.36, significant at all conventional levels).

Both Moran's *I* and Geary's *c* indicate the presence of a small, although highly significant, pattern of positive spatial autocorrelation in the data. Moran's *I* equals 0.05 (significant at the 1 per cent level) and Geary's *c* is equal to 0.89, significant at the 5 per cent. In this case, Getis and Ord's G suggests that the city to country distribution of human capital is spatially clustered across European cities, with the prevalence of cluster of cities with a high indicator, surrounded by similar cities (statistic equal to 0.52, significant at the 1 per cent level).

In other words, cities in Europe can be divided into four groups: 1. those that display high levels of concentration of skilled labour force, and where this level is even higher than their respective countries; 2. cities that display low levels of concentration of human capital, and belonging to countries with similarly low levels; and 3. the two situations in-between that may give rise to two different outcomes in Figure 3 – viz. cities having relatively low levels of human capital in absolute terms, but still represent foci of concentration in their respective countries (the cases of Portugal, Italy and Poland in Figure 3); and the other way round.

Figure 4 compares, for the relatively few observations that allow such comparison, the stock and flow dimensions of this indicator. Is there an ongoing convergence process in terms of formal education? The figure may be decomposed into four sectors, marked by the average lines for both plotted indicators. The conclusions in this case have to be treated with caution: the data cover a sample of only 76 EU cities, over a time span of only three years. However, we are able to categorize cities in four groups:

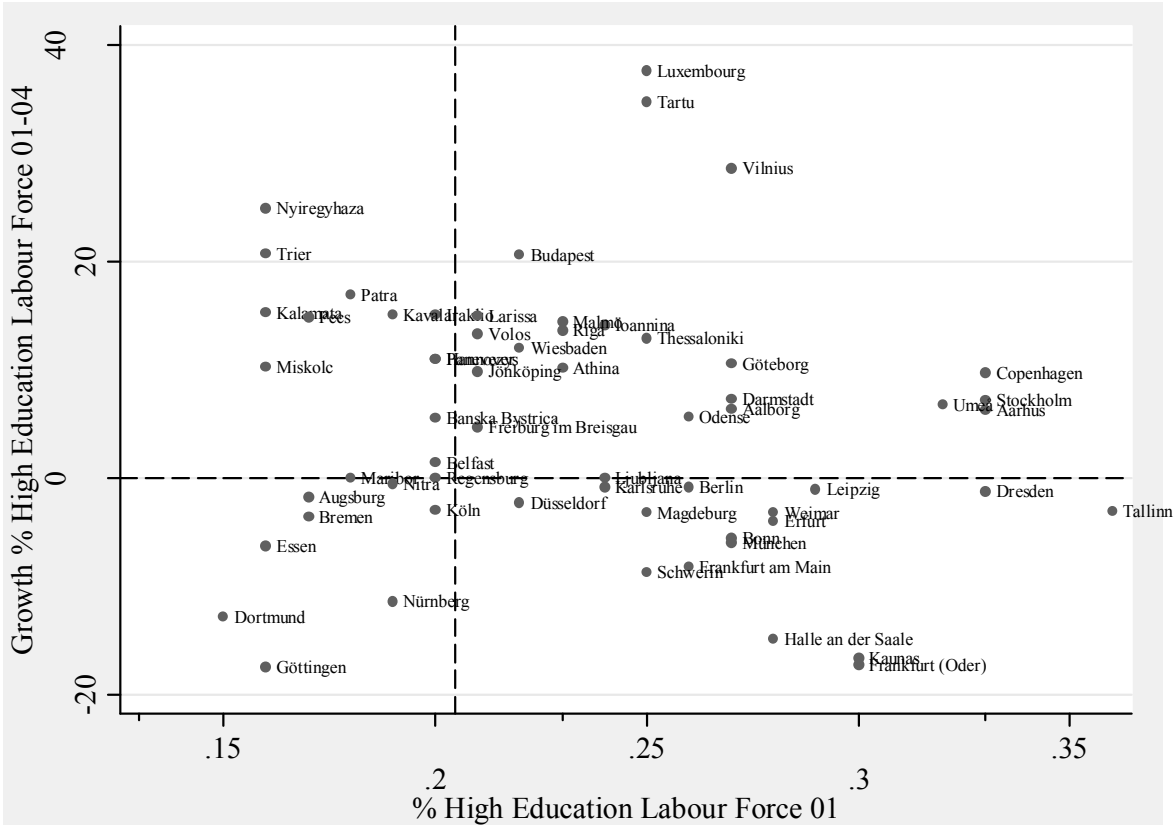

Figure 4: Education growth and levels: percentage of labour force with higher (ISCED 5-6) education, 2001-2004
Source: EUROSTAT (Urban Audit), authors' elaboration.

NW quadrant Low level, high growth: **catching up cities**.	**NE quadrant** High level, high growth: **star cities**.
SW quadrant Low level, low growth: **stagnating cities**.	**SE quadrant** High level, low growth: **stable cities**.

1. *Stagnating cities*: cities in the bottom-left corner of the graph, with both low levels and low growth of highly-educated labour force. For these cities, located both in the Eastern and Western parts of Germany, a relatively low initial level of human capital has not been followed by a catching-up process. These specific cities and others that may share the same characteristics would benefit from targeted education policy measures.

2. *Stable cities*: cities in the bottom right quadrant of the graph, where low growth followed an initially high level of educated labour force. In this case, an insufficiently dynamic pattern may hamper their initial strength, and may be a pointer for adopting more aggressive education policies.

3. *Catching up cities*: cities located in the top-left quadrant of the graph, while showing a relatively low performance in the initial year, have experienced faster than average growth of the percentage of the labour force with higher education. Cities in this group are to be found in Greece, Hungary and Germany.

4. *Star cities*: those cities that, while already enjoying high shares of educated labour force, also increased this indicator. Such cities are a heterogeneous group; and, they tend to concentrate in the Nordic and the Baltic countries, along with cities from Germany, Hungary, Greece and Luxembourg.

This section concludes with an analysis of two further indicators, based on the latest EVS survey, rather than on conventional census data. The choice of survey data introduces both improvements and risks: on the one hand, the survey data answer questions that are not in the range of regular census data. On the other hand, a potentially incorrect measurement of the phenomena being recorded may be introduced. The population representation may be biased (in terms for instance of gender, age structure, and, most relevant in the present case, education level), the number of observations may be insufficient to ensure that the sample extracted perfectly mimics the behaviour of the underlying universe.

The EVS, however, presents, in general, a sound stratification for the above-mentioned axes.[16] In this section the answer to the following question of the survey has been exploited:

> At what age did you (or will you) complete your full time education, either at school or at an institution of higher education? Please exclude apprenticeships.

The procedure of matching individual responses with cities was described in Section 4. As a result, we are able to map the average (over the urban subsample of the EVS) length of schooling of EU urban dwellers (Figure 5).

In the first case, average years of schooling reflect a partially different picture than the one shown in Figures 2 and 3. Peripheral regions (in particular, Italian, Romanian and peripheral Finnish cities) tend to display a much better performance than that emerging from Figures 2 and 3. The reason for this discrepancy may either be a country-specific tendency for respondents to incorrectly report their own education levels, thus affecting the citizens of these cities or else a difference between the population's average education level and the same indicator measured for the labour force. This, in turn, may be due to a relative underrepresentation of skilled people in the labour force of peripheral countries, a sort of market failure whereby college graduates find it more difficult to find a job in specific countries. Although the available urban data do not allow for the empirical validation of this last hypothesis, some anecdotal evidence suggests that it may not just be this case.

In fact, EUROSTAT publishes quarterly data on a comprehensive Labour Force Survey. Data covering the most recent quarters (1998/1 to 2009/3) show that in no European country does the labour force with ISCED 5 or 6 education have a lower than average employment rate. However, some signals of distress do appear from the data. In most EU countries the "unemployment

education premium", i.e., the lower expected unemployment rate for workers with higher education, steadily decreased over the period, the worst cases being Italy, Slovakia, Belgium Netherlands and Luxembourg. As a result, on average within the European Union, and in terms of probability to stay unemployed, education pays less now than in 1998, although by only about 1 per cent.[17]

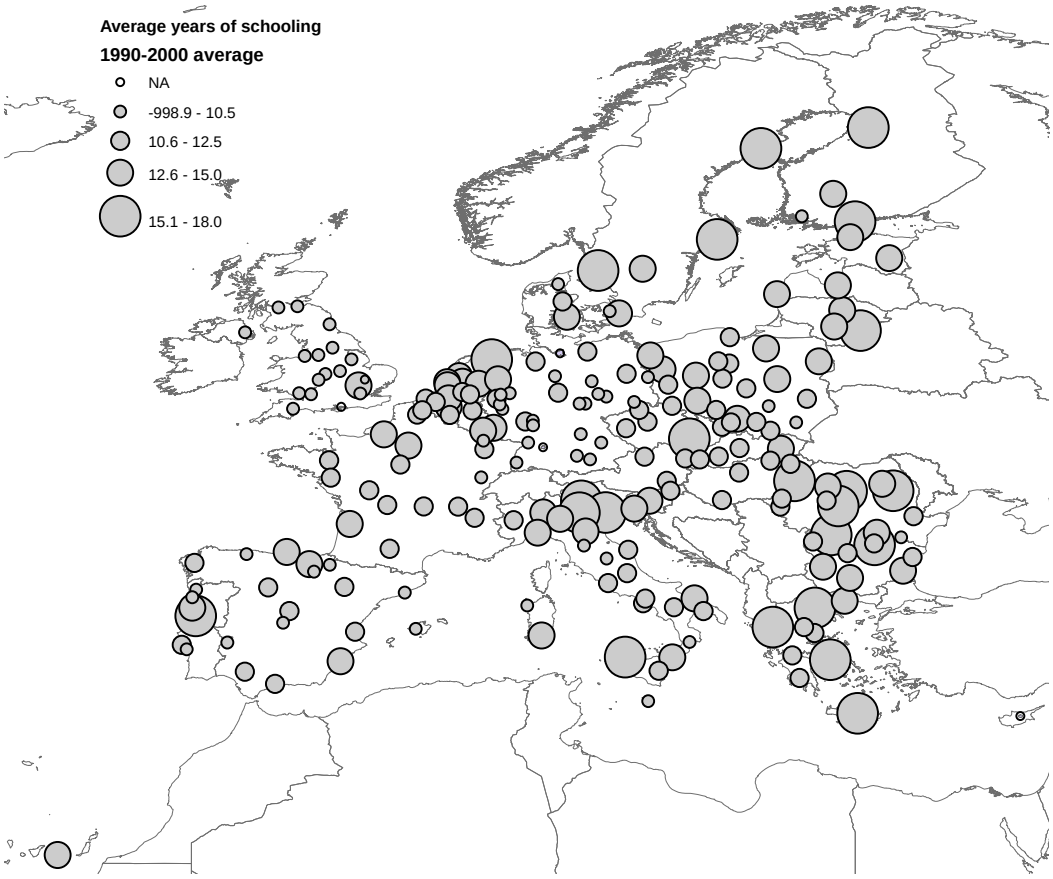

Figure 5: Average years of schooling 1990-2000
Source: EVS 1990 and 2000 waves, authors' elaboration.

The impression one gets from visual inspection, i.e., that formal education is spatially clustered in the European urban space, is corroborated by the spatial statistics. In detail, Moran's *I* and Geary's *c* both point to the presence of positive spatial autocorrelation in the data, with values of 0.06 and 0.77 respectively, and are both significant at the 1 per cent level. Notice that, in this case, Geary's c is much larger, which may be the result of the presence of outliers: single observations with very high values surrounded by many observations with very small values, or vice versa.

Looking at clustering patterns, Getis and Ord's *G* suggests a slight prevalence of negative clusters of formal education in European cities. Its value is equal to 0.32, significant at the 1 per cent level, and below the expected value of 0.33.

5.3 Sectoral composition of labour force

In this section, we adopt a different perspective on the human capital endowment of EU cities with respect to formal education, and explicitly consider the skill content of employment in urban areas. By adapting the taxonomies proposed by Pavitt (1984) and Evangelista (2000), we will consider the proportion of workers in the high-skills service sectors, proxied, in our framework, by employment in financial intermediation, business activities (NACE sectors J and K), public administration, health and education (NACE sectors L, M and N). Pavitt classifies innovative firms on the basis of their technological trajectories, and includes the public sector in the science-based group. Evangelista extends and adapts this taxonomy to the service sector, classifying sectors as technology users: S&T-based, Interactive and IT-based and Technical consultancy. By highlighting the different dimensions of innovative activities of firms operating in these groups, the author has provided a guideline for identifying the high-skills service sectors. We borrow from his classification and consider the proportion of employment in financial intermediation and business activities. We therefore consider employment in NACE service sectors L-N as skill-intensive. Combining the information on these groups of sectors, we can identify the percentage of urban employment in the high-skills sectors.

While we could expect a rather uniform distribution of these activities across EU cities, from inspection of Figure 6 this is clearly not the case. Our prior on spatial homogeneity could be justified on the basis that these activities typically take place in cities (Duranton and Puga, 2005), but there is in reality a high degree of heterogeneity across the EU. Cities in Northern France, the UK, Belgium, the Netherlands, Denmark, Germany and Scandinavia are characterized by an average percentage of employment in these sectors of over 50 per cent. On the contrary, cities in the New Member States (NMS) and in the southern parts of Europe have a much lower proportion.

The high-skilled employment displays clear evidence of positive spatial autocorrelation and clustering in our sample, based on all three statistics considered, with statistically significant values at the 1 per cent level. The Moran's I statistic is equal to 0.25, together with a value of Geary's c of 0.708. Getis and Ord's G, with a value of 0.50, above its expected value, indicates the presence of relevant positive clustering, largely confirming and strengthening our general arguments on the spatial patterns of this dimension of human capital endowment in EU urban areas.

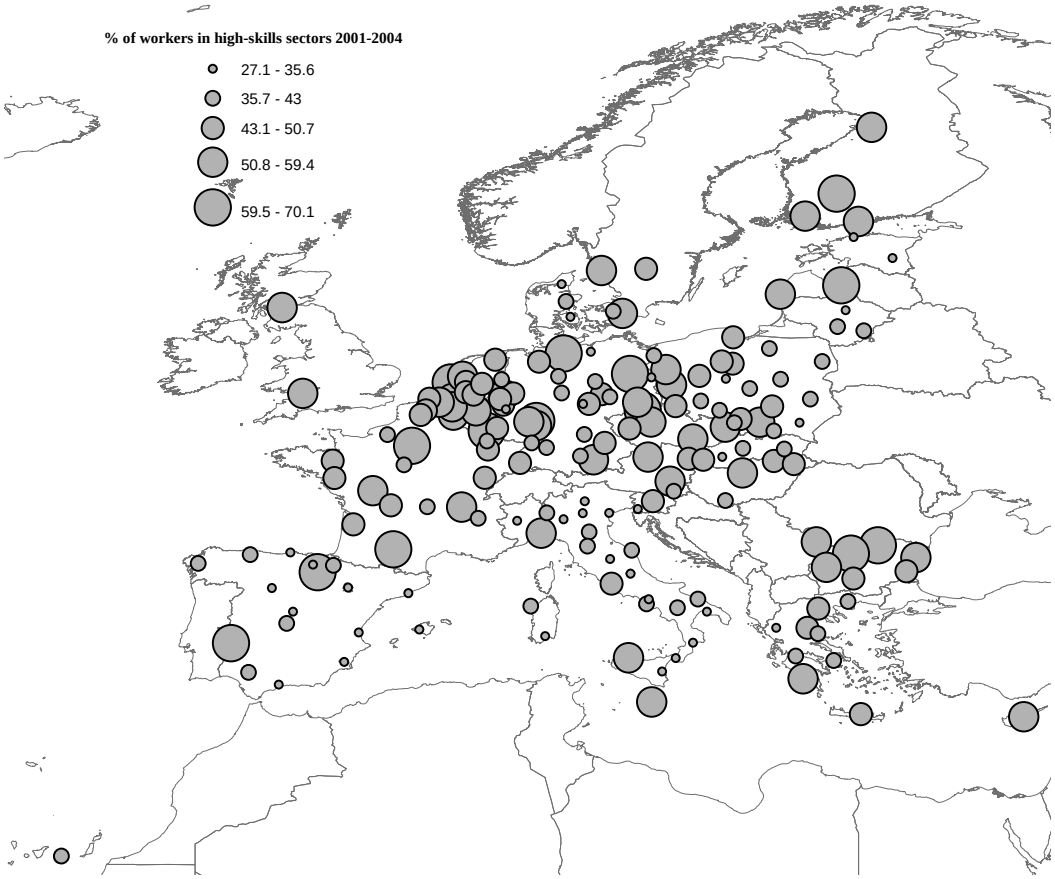

Figure 6: percentage of workers in the high-skills sectors, 2001-2004
Source: EUROSTAT (Urban Audit), authors' elaboration.

Note: *Percentage of employment in financial intermediation and business activities (NACE sectors J and K), public administration, and health and education (NACE sectors L, M and N). 2001-2004 data.*

By considering the process of tertiarization between 2001 and 2004, in Figure 7, i.e. the growth of the service sector, some interesting patterns emerge. Overall, an evident tertiarization of the economy is taking place, with a few notable exceptions. Some cities in France and Spain, in the Netherlands and Denmark, and in Bulgaria and Cyprus, show a negative growth or decrease of the high-skills sector.

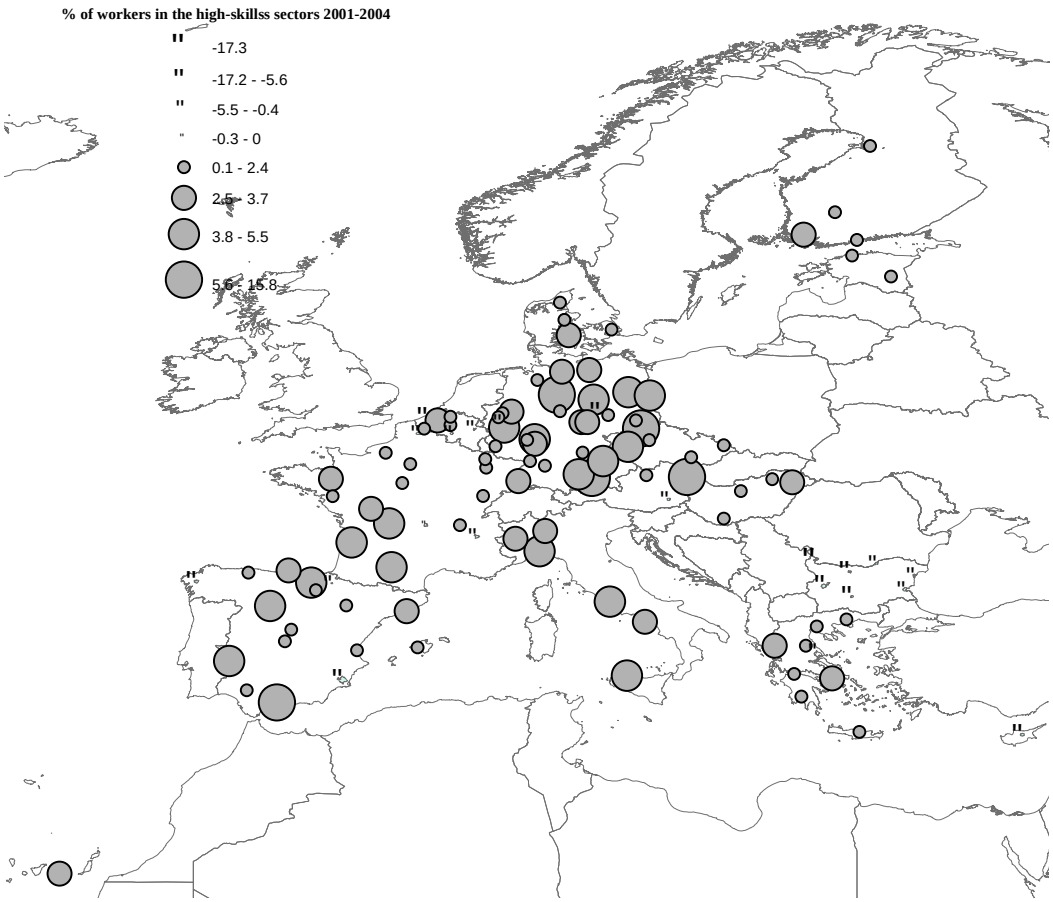

Figure 7: Tertiarization between 2001 and 2004
Source: EUROSTAT (Urban Audit), authors' elaboration.

***Note**: growth in the percentage of employment in financial intermediation and business activities (NACE Rev 1.1: J-K), public administration, and health and education (NACE Rev 1.1: L-N) between 2001 and 2004.*

Looking at the tertiarization process occurring in the EU at the urban level between the years under consideration, there is evidence of a slightly positive spatial autocorrelation process (Moran's *I* statistic of 0.02, significant at the 1 per cent level, and Geary's *c* index of 0.82, significant at the 10 per cent level), while there is a strong and significant indication of positive clustering. Getis and Ord's *G* statistic, significant at the 1 per cent level, is equal to 0.89, almost twice the expected value. In that representation, a clear cluster of cities with a rapidly growing service sector is present in the Northern-Central area of Europe, while a smaller negative cluster is detectable in Bulgaria.

In Figure 8 we analyse the sectoral composition of employment in capital cities, by decomposing the workforce in five macro-sectors: Agriculture and fishery (NACE Rev 1.1: A-B); Mining, manufacturing and energy (NACE Rev 1.1: C-E); Construction (NACE Rev 1.1: F); Commercial services (NACE Rev 1.1: G-K); and Other services (NACE Rev 1.1: L-P).

In general, the service sector, especially commercial services, is a relevant component of all EU capital cities, with the highest percentage (70.5 per cent) in Milan, Italy and the lowest in (27 per

cent) in Pleven, Bulgaria. The main differences in the urban sectoral composition can be better inferred from the importance of the manufacturing and energy sector.

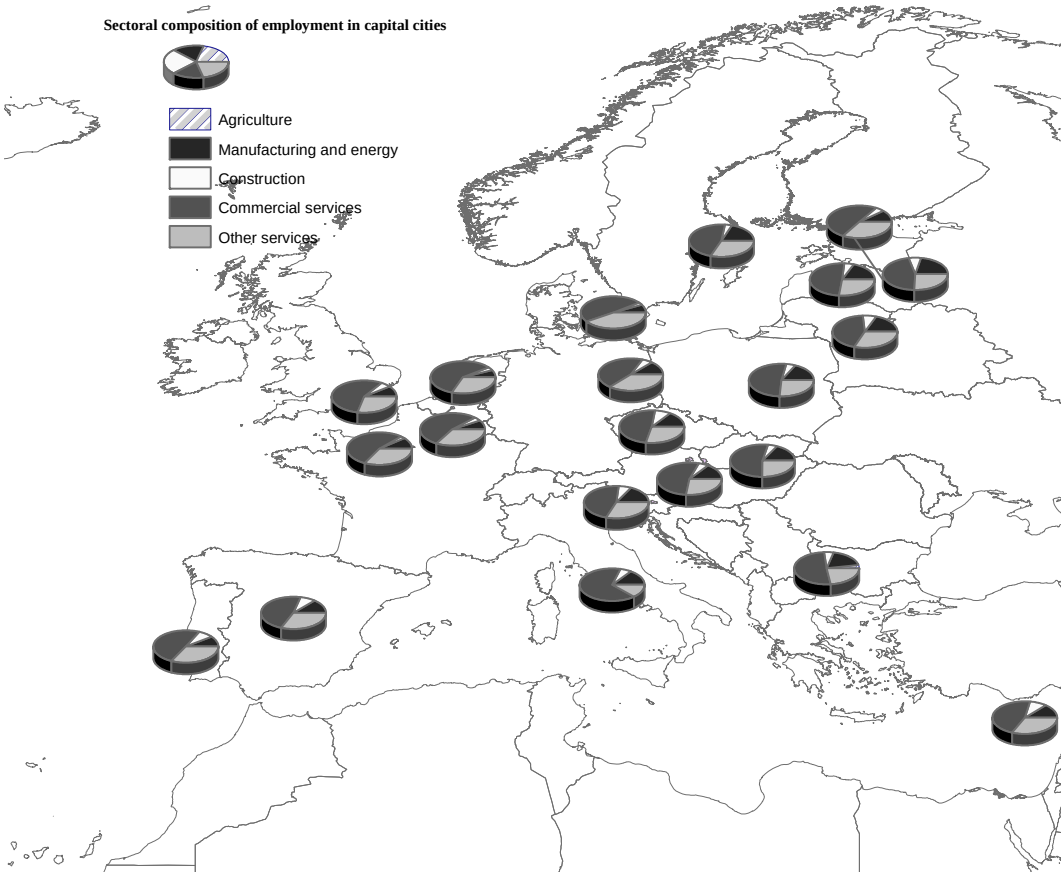

Figure 8: Sectoral composition of employment in capital cities, 2001-2004
Source: EUROSTAT (Urban Audit), authors' elaboration.

***Note**: percentage employment in the following five sectors: 1.Agriculture and fishery (NACE Rev 1.1: A-B); 2. Mining, manufacturing and energy (NACE Rev 1.1: C-E); 3. Construction (NACE Rev 1.1: F); 4. Commercial services (NACE Rev 1.1: G-K); 5. Other services (NACE Rev 1.1: L-P).*

How are traditional human capital indicators (in this case, average years of schooling) related to the presence of workers in the high-skills sectors? Is this relationship always positive? And can we say that one leads to another? A quick glance at Figure 9 clearly suggests a negative answer, calling for a closer look at the true patterns in EU cities.

The top-right quadrant identifies cities with a significant human capital endowment and the presence of qualified employment in the high-skills sectors. The countries included in this group are quite varied, and belong both to Old and New Member States. These cities are rich in human capital, where a combination of formal education levels and the high-skilled employment is present.

The bottom-left quadrant depicts the situation of cities that are somewhat lagging behind, with low levels of both indicators, but possibly, potential for improvement. These cities, mainly located in Italy, Spain, France, Germany and Poland, could benefit from appropriate and well designed

education and training policies, and could also be candidates for the attraction of innovative and dynamic firms.

The remaining quadrants identify two very different types of cities. Cities in the bottom right quadrant can be expected to become top performers in the high-skills sectors thanks to the presence of a highly-educated labour force. Finally, the top-left quadrant, groups cities that are characterized by a dynamic workplace, with a high percentage of employment in the high-skills sectors, but relatively low levels of formal education.

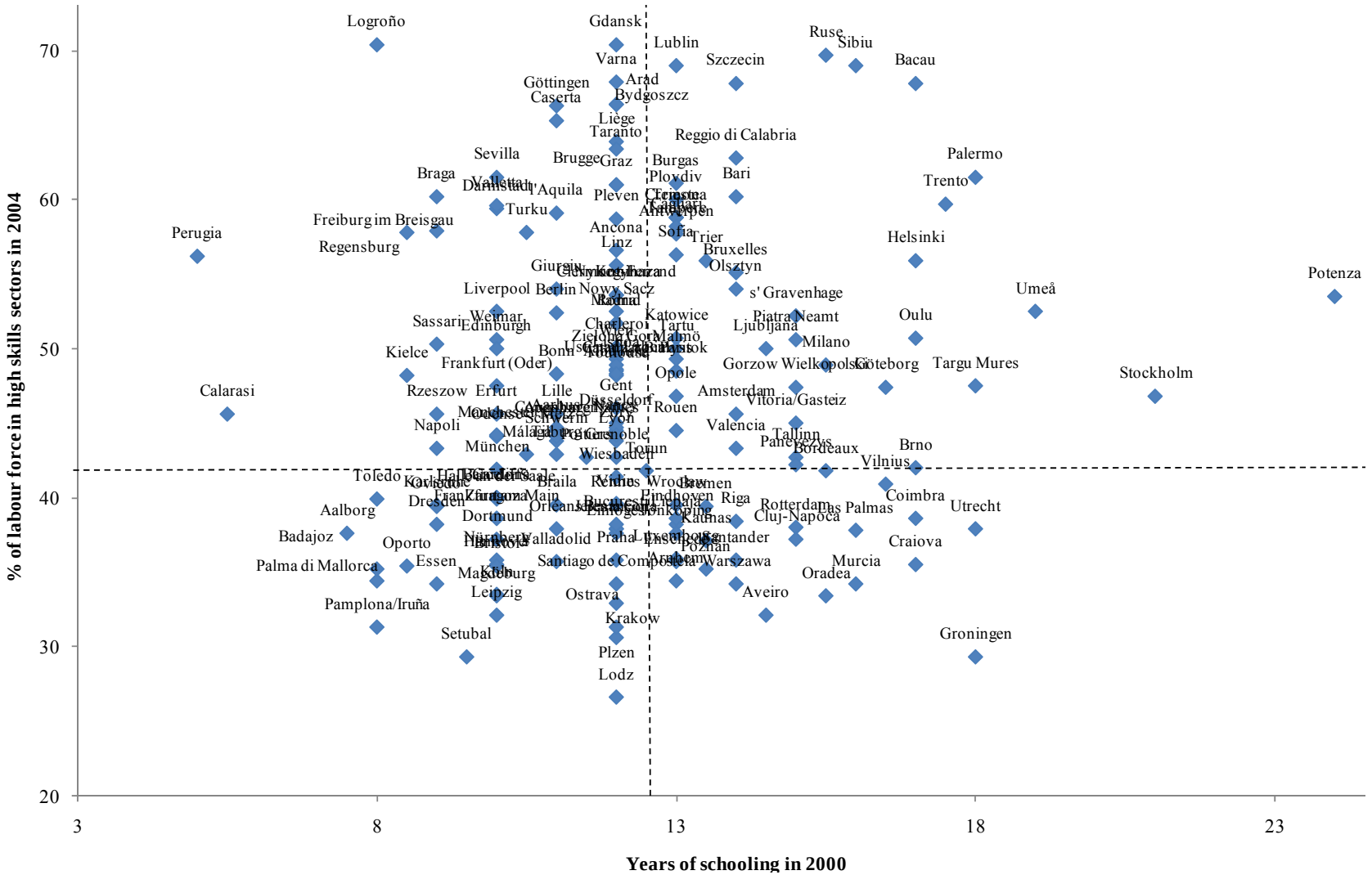

Figure 9: Formal education and sectoral composition, 2000-2004

Source: EUROSTAT (Urban Audit),and EVS 2000 wave, authors' elaboration.

***Note**: average years of schooling and percentage of employment in financial intermediation business activities (NACE Rev 1.1: J-K), public administration, health and education (NACE Rev 1.1: L-N) between 2001 and 2004.*

5.4 Creativity and tolerance

Today's cities are in a way hard to compare to early urban agglomerations of the late 18th and early 19th centuries. As the main places where innovation takes place, cities have attracted, within each country, the part of the population that is most interested to innovate. Still, in some sense, today's cities are much like their predecessors: they need skills. However, as already pointed out, human capital has already consistently flown to cities, which now display much narrower differentials in terms of average years of schooling, and labour force engaged in innovative activities and employed in human capital-intensive sectors. Therefore, recently, a new wave of research has underlined the relevance of creativity and the major importance of workers in the creative industries as a main source of competitive advantage. This research produced, in particular, the seminal Florida (2002) book, which pointed at creativity, tolerance, and specialization in the entertainment industries as the real modern indicators of urban success. The book's main conclusions have been summarized in Glaeser's review on *Regional Science and Urban Economics* as follows:

"Florida's basic thesis is that the economy is transforming, and creativity is to the 21st century what the ability to push a plow was to the 18th century. Creative occupations are growing and firms now orient themselves to attract the creative. Employers now prod their hires onto greater bursts of inspiration. The urban lesson of Florida's book is that cities that want to succeed must aim at attracting the creative types who are, Florida argues, the wave of the future" (Glaeser 2005, p. 593).

However, as already suggested, this view, which has met with huge success not only among academics, but also with policy makers, does not necessarily hold true in contexts other than the US where it was first conceived. In fact, it is hard to compare EU cities with creative places as San Francisco, Austin, Chicago, Seattle (to mention just a few examples).[18] This statement can be supported by figures. The share of employment in what is called "creative class" in major European cities can scarcely be compared to that recorded in metropolitan areas in US counties. Table 2[19] shows a comparison of the employment share of the creative class in non-US cities and US counties for the period 2000-2001.

Table 2: Creative class employment shares in non-US cities and US counties, 2000-2001 (in percentage)

Non US	% employment in creative class*	Country	US	% employment in creative class*	State
Stockholm	45.75	Sweden	Los Alamos County	54.07	NM
Auckland	42.36	New Zealand	Falls Church city	53.20	VA
Sapporo	37.25	Japan	Douglas County	48.09	CO
Amsterdam	36.05	Netherlands	New York County	47.88	NY
Montréal	35.03	Canada	Arlington County	47.54	VA
Brussels	32.25	Belgium	Collin County	45.71	TX
Copenhagen	30.26	Denmark	Howard County	44.86	MD
Sydney	27.79	Australia	Marin County	44.84	CA
Barcelona	24.37	Spain	Fairfax County	44.82	VA
Milan	24.35	Italy	Alexandria city	44.55	VA
Lyon	22.99	France	Loudoun County	44.11	VA
Lisbon	21.42	Portugal	Montgomery County	43.83	MD
Athens	20.94	Greece	Hamilton County	42.62	IN

Source: Urban Audit and US Department of Agriculture Economic Research Service, own elaboration.
** Definition of the creative class available at http://www.ers.usda.gov/data/creativeclasscodes/methods.htm.*

Table 2 shows that US metropolitan areas, ordered by decreasing importance of the creative class, can be compared only to a few major EU urban areas. Actually, Hamilton County (IN), which ranks 13th in this list, has more than twice the share of the creative class than Athens, which occupies the same position in the non-US list.

Moreover, the very notion of creativity as opposed to a more traditional, education-based view of human capital has been called into question. Would having more workers in the creative industries imply higher growth rates? This question can be seen from a rather different perspective. Creativity in cities implies not only a sectoral concentration of workers in the creative industries. It also encompasses a more complex and long-lasting comparative advantage, made up of tolerance and the wide availability of urban amenities that are capable of further attracting educated workers.

For all these reasons, and despite the different frameworks in which the creative class theory was born and will now be adapted, it is logical to assess the spatial distribution of indicators related to this specific approach. This is done here with two major proxies for the creative class: the average employment in the creative industries, and the tolerance towards homosexuality.

As suggested in Section 3, a major axis to the modern notion of creativity and creativity capital is that of tolerance. Cities rich with workers in the creative industries would in general be associated with a more tolerant attitude towards any form of diversity. This would be interpreted as a sort of urban amenity, and would eventually represent a major competitive asset for cities aiming to attract human capital, and compete in this field with other major urban centres.

Figure 10 maps one such indicator, viz. the stated tolerance of homosexuality. EVS respondents were asked, among others, the following question: "On a 1 to 10 scale, how much is homosexuality accepted?". Therefore, the figure maps with the larger symbols a more relaxed attitude towards homosexuality. Such a relaxed approach can be clearly found in the BENELUX countries, in South-East England, Northern Italy, and in Germany and Denmark. On the other hand, a less tolerant climate is found in some New Member States (noticeably, Romania, Bulgaria and Poland) and in some cities (such as Lisbon, Oporto, Valencia and Madrid) in the Iberian peninsula.

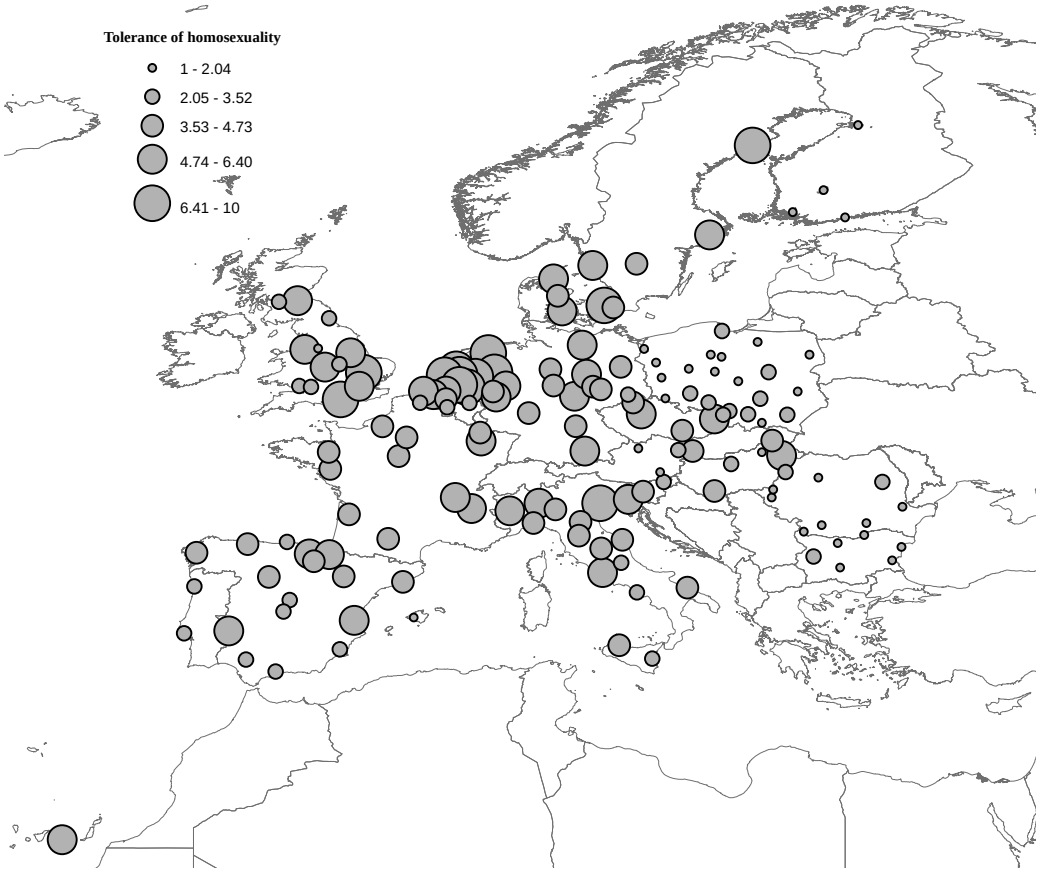

Figure 10: Tolerance of homosexuality
Source: EVS 1990 data, authors' elaboration.

Evidence in favour of positive spatial autocorrelation with respect to the creative side of human capital can be found by looking at spatial statistics for the indicator of tolerance towards homosexuality, with a Moran's I index of 0.18 and Geary's c of 0.75, both statistically significant at the 1 per cent level. Getis and Ord's G statistic, which is equal to 0.54, highly significant at the 1 per cent level, favours the view of positive clustering of the data.

5.5 Connectivity and urban knowledge capital

Cities are becoming increasingly "global" around the world, a concept that has been analysed in Sassen's (2001) book, *The global city*. In this view, cities have regained, after a period of stagnation in the 1970s, when manufacturing in cities lost momentum and the service sector started to emerge

as the new leading specialization of cities, the role of strategic centres for multinational firms' headquarters, for the business and financial sectors, and attractors of the creative and cultural industries. Increasing interdependencies between businesses, nations and people have also fostered the creation of networks and connections between global cities. This dynamic interplay between the increasing presence of the high-skill, creative and international firms and workers in cities is closely related to the broad definition of urban human capital endowment, and can be defined as "urban knowledge capital"[20] that defines the functional urban hierarchy proposed by Davoudi (2003).

Hence, in this Section we examine EU cities under this lens, and assess their status and potential as global cities with sizeable urban knowledge capital by using data on the presence of global service firms[21] and connectivity in 2000.[22] The European cities considered for the following analyses are a subset of the world-wide global cities present in the GaWC data sets and include national capital cities along with some large and international cities for each country.

How can we link the concept of the global and connected, networked city with the traditional notion of human capital? The presence of global service firms (Figure 11) for the high-skills sectors such as accountancy, advertising, banking and finance, insurance, law management and consultancy is clearly associated with a concentration of a highly-qualified, experienced and educated workforce,

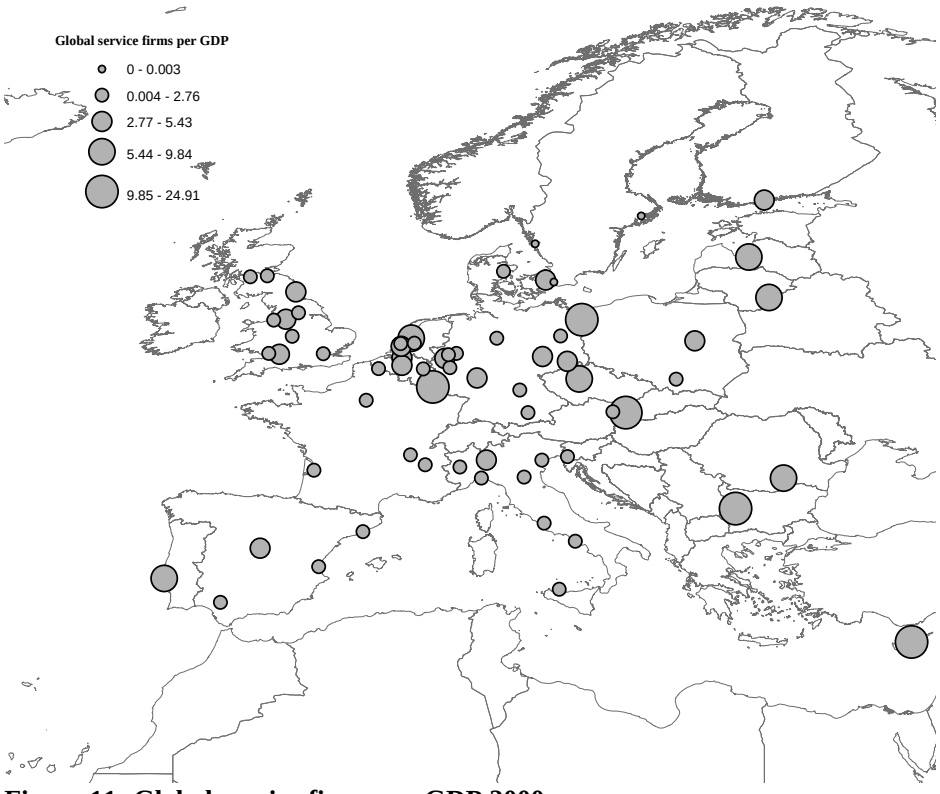

Figure 11: Global service firms per GDP 2000
Source: GaWC, authors' elaboration.
***Note**: data set 11 GaWC. Number of offices of global service firms in each city per 1 billion GDP.*

This directly contributes to enhancing a city's human capital stock. Considering the number of global service firms in European cities in 2000, related to GDP, presents an interesting and spatially diversified snapshot of the EU.

In this case, the two spatial autocorrelation statistics are statistically insignificant, while no clustering seems to be relevant when considering Getis and Ord's *G* statistic, with a positive, but below the expected value, figure of 0.48, significant at the 10 per cent level.

The concept of a world city network has been put forth and analysed empirically by Taylor et al. (2002) and is based on Sassen's research (2001) on the role of the city in a globalized economy. An interconnected city is well equipped to face the challenges of an ever-changing economic situation, aided by its ability to use a network of formal and informal connections to enter new markets, meet varying and novel consumer demands and contribute to the overall local and national economic growth. Figure 12 shows the GaWC measure of connectivity. This measure is computed by means of a "standardized measure of the importance of a city to a firm's office network, which depends upon the size and functions of an office or offices in a city".[23]

This measure of the extent of a city's network is therefore once again closely related to human capital, as it is based on the above-mentioned definition of global service firms.

An interesting result highlights the strength of traditional global cities (e.g. London, Brussels, Amsterdam, Paris, Berlin) along with an increasing role for major cities in the NMS. This result is also confirmed in Derudder et al. (2009), who report a gain in global productivity of Eastern European cities**.**

For this indicator, very much in line with the considerations for the network dimension of human capital examined by considering the number of global service firms, all three statistics are insignificant.

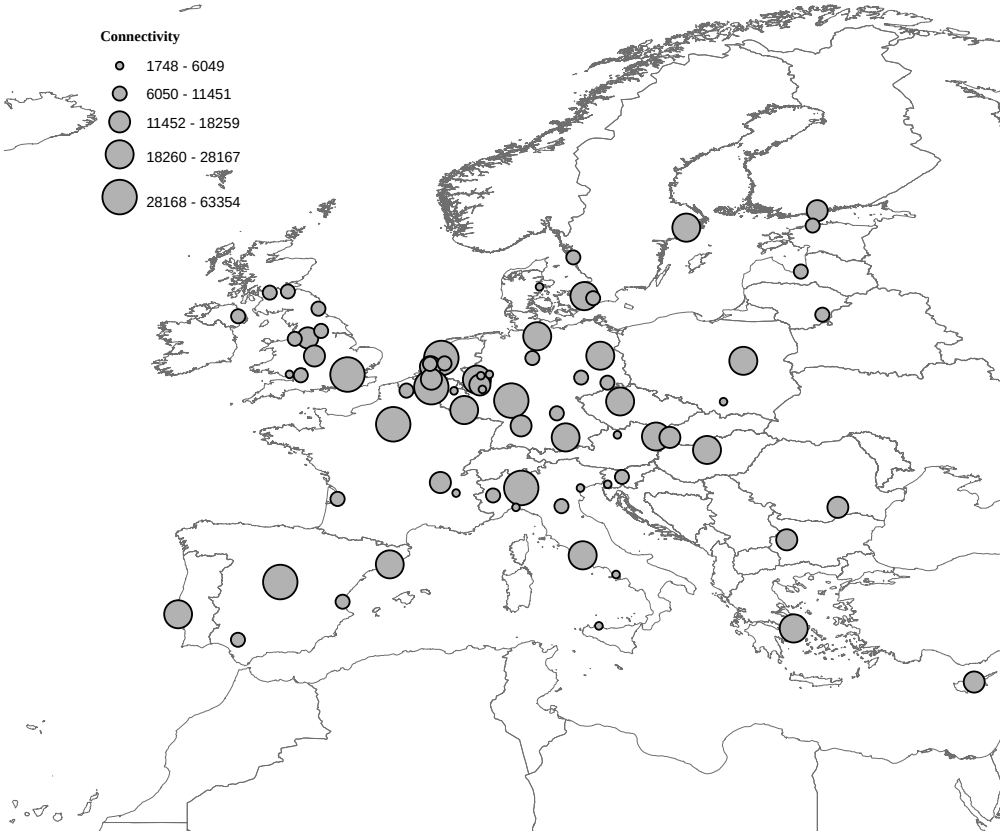

Figure 12: Connectivity 2000
Source: GaWC, authors' elaboration.
***Note**: Data set 12 GaWC. Number of connections based on global service firms in each city.*

6. Lessons and future research

This last Section summarizes the lessons from this paper.

Data show that the notion of human capital is much richer than is usually believed. The methodological literature review in the first part of the paper shows that human capital has mainly been conceived in terms of formal education. Recent developments, however, point towards sectoral composition, creativity and urban hierarchy issues. This line of research is summarized in Figure 13, where along with traditional education-based theories, the sectoral composition of the labour force, and creativity also represent useful dimensions of the concept of human capital. Somewhat complementary to the three above definitions is the notions of functional urban hierarchy and urban knowledge capital, which aim to capture the "power centre" conceptualization of urban areas. In fact, cities where the main control centres, R&D facilities, marketing, and quality control structures are located also tend to display high concentration of formally-educated workers, in human capital-demanding sectors, and in the creative industries.

Figure 13: A classification of four human capital dimensions.

The empirical analysis presented in Section 5 has provided a map of human capital in EU cities in terms of this classification and taxonomy, and several interesting conclusions and lessons can be drawn from the picture that emerges. We can derive useful conclusions in terms of:

- a conceptualization of a richer definition of human capital, broken down along several dimensions, highlighting interrelations, juxtapositions and the differences between them;
- a spatial analysis of the distribution of human capital in the European urban framework, useful for determining common trends, the clustering and the heterogeneity of the human capital endowment;
- directions for future research with respect to policy design aimed at fostering and improving the situation of European cities in terms of human capital endowment, in light of its widely recognized role as a major endogenous determinant of economic growth.

In order to systematically review the lessons learned and highlight the potential problems related to data availability and cross-country comparability, Table 3 provides a summary of the main concepts and indicators used in this study, suggesting possible solutions for future research.

Human capital is a complex concept, with different potential definitions and dimensions. This leads to difficulties in empirical analyses in terms of the identification of proper proxies and indicators. We have tried to overcome this issue by identifying four main axes along which to measure urban human capital and by using a set of indicators for each dimension. We aimed at EU-wide coverage, and have exploited three comprehensive data sets for European cities (Urban Audit, EVS and GaWC). As highlighted in the main text and in Table 3, complete comparability of indicators is not always possible, due to different data coverage both across and within data sets. Another potential problem is related to the lack of data for smaller EU cities, because of the underlying sampling choices in the original data collection by EUROSTAT and GaWC. We have tried to overcome the first problem by maximizing the comparability of data sets in terms of cities included in the analysis by using all information available and by careful data mining. We also believe that our mapping exercise, and the accompanying spatial statistical analysis, provides an informative picture of Europe's urban human capital stock. The problem of the lack of data for smaller EU cities for all indicators, however, could not be overcome since our sources of data focus only on medium and

large cities. We believe this to be an important issue and we advocate data collection in small EU cities as well from national statistical offices and EUROSTAT.

Table 3: Dimensions of urban human capital-lessons learned and directions for future research

Core dimensions of human capital	Indicators	Data Availability	Potential bias	Possible solution
Formal education	Years of schooling; High education workers.	Source: UA, EVS. Data coverage: medium and large EU cities.	The fact that medium and large cities attract workers with higher education along with the presence of universities may cause overestimation of formal education.	Surveys should collect information on formal educational attainemt in smaller EU cities.
Sectoral composition of labour force	Employment in high skills sectors.	Source: UA Data coverage: medium and large EU cities.	High sills sectors may be concentrated in medium and large cities.	Surveys should collect information on the composition of the labour force in smaller EU cities.
Creativity	Employment in entertainment industries; Tolerance.	Source: UA, EVS. Data coverage: medium and large EU cities.	Creative sectors and people may be concentrated in medium and large cities.	Surveys should collect information on the creative capital in smaller EU cities.
Urban knowledge capital	Presence of global firms; global networks.	Source: UA, GaWC. Data coverage: large EU cities.	Global firms concentrate in larger cities.	The presence of global firms and networks should be recorded also for medium and smaller cities.

Policies that aim to increase the endowment of human capital in European cities can derive some interesting conclusions from this paper. Since the inception of the Lisbon Strategy in 2000 (European Union 2000), policy makers have committed resources and academics have made an intellectual effort in order to improve our understanding of European innovation performance, and consequently to make Europe "*the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic (...) by 2010*". Now at the end of that period, this goal is far from being reached. In some cases the gap between EU countries and regions and the top world performers is even wider now than 10 years ago. From an academic point of view, this relative failure may be at least partially due to an insufficient knowledge of the complex nature of knowledge and human capital at the basis of EU policies.

This paper contributes, therefore, to this debate by shedding new light on the intertwined nature of different notions of human capital, all necessary to achieve the innovation goals set by the Lisbon

Strategy, as well as by showing the inherently spatial disparities affecting EU cities in terms of human capital distribution.

Recent policy documents, while reporting the EU's insufficient performance in terms of the Lisbon Strategy, have arrived at similar conclusions. In the words of the President of a think tank committed to "defining and articulating a mature strategy for managing current and future challenges"[24] of the EU:

> *"We must make sure that knowledge is not the sole property of the elites, but it is broadly disbursed among the population, giving people the power to invent new ways of organizing work, new ways of collaborating to add value, new ways of attaining personal fulfillment, new ways of thinking constructively in a world where the ability to create and deliver new, forward-looking ideas will determine success"* (Hofheinz 2009).

Moreover, today's knowledge and human capital are different from yesterday's. International cross-country evidence suggests that workers take on tasks that are more and more complex; work is becoming less routine, and a more challenging and skills-demanding activity. In the US context, for instance, Levy and Murnane (2004) show that an increasingly larger share of job tasks are focusing on non-customary cognitive, manual and interactive skills. People do not only need to know; they also need more and more to keep on learning, be curious, adapt to different situations, and solve complex problems. In other words, "*the best knowledge that an individual can possibly acquire (...) is the recognition that a brain is a rechargeable tool which can and should be built up and improved upon throughout a lifetime*". This ultimately leads to the scope of our paper, viz. identifying a richer set of definitions and indicators of human capital, in a world where Europe is no longer the most educated place: "[Policy makers] *should strive to see the holistic, multi-dimensional aspects of a complex, modern skills agenda, i.e., many things outside the realm of education and education spending have a direct effect on a country's human-capital base.*"[25]

Furthermore, in terms of spatial planning, Van Winden (2010) identifies four major axes along which planning is increasingly focusing on knowledge and human capital, viz. the increasing tendency of global cities to lure knowledge workers; a growing inclination of knowledge institutes to take part in urban planning processes; an explicit knowledge-based approach to planning; and the massive efforts of several local boards to market themselves as a "knowledge city".

In order to fulfill policy objectives, we need more research on this topic, and our paper is just the first step in such a direction. Research needs to be based on better data. Evidence on non standard classifications of human capital is scarce, and particularly so for European cities.

The Urban Audit project is a relatively recent and interesting attempt to fill this gap from a standard statistical perspective. Nevertheless, much more information is also needed on issues that, while having been insufficiently explained, are mostly covered by large surveys. This paper exploits two waves of the European Values Study; similar information is also collected by Eurobarometer and the International Social Survey Programme surveys. However, the absolute number of citizens being interviewed is just not sufficient to draw completely accurate conclusions on the spatial, educational, gender and, above all, sectoral distribution of the EU population. Much as in other fields of research, the collection of larger individual data sets at different spatial scales and with fully stratified samples (over different dimensions) may offer researchers a more solid ground to walk on, and therefore supply policymakers with stronger theoretical *a priori*.

This paper represents a crucial point of departure for such research. Since the Scientific Revolution, European cities have been at the forefront of world technology. Human capital has always been attracted to places where the quality of life is high, salaries are relatively competitive and urban amenities are easily available. However, in all these aspects European cities have been showing a relative slowdown with respect to potential world competitors. The uneven spatial distribution of human capital, which is deduced in all four definitions presented in this paper, already provides evidence of the possibility to be more or less successful in the quest for attracting knowledge and creative workers in cities of the EU. A crucial next step is therefore a careful modeling of the main causes of EU urban performance, possibly making a partial departure from the main assumptions of urban growth models designed for different contexts. Future research may therefore move towards identifying a dedicated set of hypotheses that are more apt to increase our understanding of EU urban growth patterns, and which should be tested along the directions laid down in this paper.

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[1] The capital stock has been built with the perpetual inventory method, assuming a constant yearly depreciation rate of 2.5 per cent, and taking 1960 (when possible) as the base year.
[2] This statement will also be substantiated with quantitative evidence in this paper.
[3] A notable exception, from a rather different perspective, is Hohemberg's (2008) chapter in the *Handbook of Regional and Urban Economics*.
[4] The evidence of a positive relation between human capital investment and economic performance is overwhelming. A recent interesting contribution to this burgeoning literature is OECD (2009), where the estimated public returns to education (i.e. the net present value of obtaining for a male upper secondary or post-secondary non-tertiary education and tertiary education) is estimated to be equal to about $50,000 (about €35000 at the January 2010 exchange rate).

[5] This figure and those following in this section are obtained as follows. Countries in the Barro-Lee schooling data set are divided in seven geopolitical areas: Advanced countries; the Caribbean; Africa; East Asia and the Pacific; the Middle East; South Asia; and the Transition economies. Group averages and standard deviations are then calculated for each year (with 5-year lags) for which Barro-Lee statistics on schooling are available – viz. 1950, 1955, 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995 and 2000. Finally, these figures are compared across time and space, the time index being as indicated, and space being identified by the 7 macro-regions previously listed.

[6] Under the non restrictive assumption that innovation is more skill-intensive than imitation.

[7] In particular, see Edward Glaeser's skeptical perspective on the notion of creative class as opposed to more traditional measures of human capital in Glaeser (2005).

[8] More information on this data set can be found on the project's official website: http://www.urbanaudit.org/index.aspx

[9]ISCED (Unesco) levels 5 and 6 capture, respectively, students in the first stage of tertiary education (not leading directly to an advanced research qualification) or in the second stage of tertiary education (leading to an advanced research qualification).

[10] The data were produced by P.J. Taylor and G. Catalano, and constitute Data Set 11 of the Globalization and World Cities (GaWC) Research Network (http://www.lboro.ac.uk/gawc/) publication of inter-city data.

[11] The data were produced by P.J. Taylor and constitute Data Set 12 of the Globalization and World Cities (GaWC) Research Network (http://www.lboro.ac.uk/gawc/) publication of inter-city data.

[12] See Geary (1954).

[13] Getis and Ord (1992).

[14] The European Spatial approach is based on the European Spatial Development Perspective document (see European Union 1999).

[15] UNESCO data actually show some worsening of education data for certain New Member States after the collapse of the USSR. In particular, in Romania and Bulgaria youth (citizens aged 15-24) literacy rates dropped by a couple of percentage points between 1992 and 2007. Analyses of the World Bank's World Development Indicators (WDI) show that Romania's rank in this specific indicator dropped from the 22nd to the 46th place between 1990 and 2006, whilst Bulgaria's position slipped from the 19th to the 37th position in this special ranking. Emigration of skilled workers to richer EU countries may be held partially responsible for this decreasing trend.

[16] For more information on the EVS stratification procedure, see Halman (2001).

[17] Source of raw data: EUROSTAT, Labour Force Survey. Authors' calculation.

[18] On Richard Florida's website (www.creativeclass.com) a section collects information on creativity issues in the cities of the website users. On 19 January 2010 the list of cities from where information was sent includes only 15 EU cities, out of a total of 128 examples, while all major US cities in terms of population took part in this survey.

[19] Data on the non-US share of workers in the creative class are elaborated by Kevin Stolarick, Carnegie Mellon University, and are presented in Tinagli and Florida (2005).

[20] Sassen (2008).

[21] A comprehensive list of global service firms surveyed in this data set is available upon request from the authors.

[22] GaWC data, described in Section 3.

[23] Derudder et al. 2009, page 3.

[24] From the Lisbon Council website, retrieved on 22 January 2010 at the URL http://www.lisboncouncil.net/about-us/vision.html.

[25] These last two citations were both from Hofheinz (2009).

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