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## Sub-centres and Urban Inequality: A study on Social Equity in the Barcelona Metropolitan Region

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# “Sub-centres and Urban Inequality: A study on Social Equity in the Barcelona Metropolitan Region”

Masip Tresserra, Jaume†\*

## ABSTRACT:

Much of the inequality literature has done a great deal of work to study national inequality. However, most people live in cities and their experience of inequality is shaped by their local and metropolitan environment. This fact implies that next to inequality in countries, local inequality is also important. In this context, this paper investigates the relationship that exists between the urban spatial structure (defined by means of CBD and sub-centres) and the causes and the consequences of urban inequality in cities. To do so, this research takes into account the Barcelona Metropolitan Region as study case.

Hence, the aim of this work is to determine whether CBD (central business district) and in particularly sub-centres, exert an influence on urban inequality in order to define future policies that enhance social equity. What determines the degree of inequality across the municipalities of the Barcelona Metropolitan Region and, what are the factors behind the inequality growth across these municipalities?. The former question is addressed through using spatial econometric techniques that estimate if per capita income in 2008 is dependent on the past agglomeration economies that have emerged from CBD and sub-centres in 2001 correspondingly. Consequently, the latter point is also studied, through examining whether urbanization and localization economies that have emerged from CBD and sub-centres in the past, matters for the per capita income growth between 2001 and 2008.

The results suggest that agglomeration economies that arise from CBD and sub-centres can explain the degree of income inequality and its growth as well. In addition, once is controlled for other conditions, the econometric models reveal that initial income inequality, population density, presence of human capital, land use balance, urban amenities and coast location are positively associated with per capita income as well as they predict its growth until 2008. Inversely, high level of elderly population is negatively significant correlated with per capita income and its growth. Therefore, planning a metropolitan area by taking into account sub-centres entail a remarkably improvement of its social performance.

## KEYWORDS:

Urban structure, urban inequality, polycentrism, sub-centres, social equity, per capita income & metropolitan areas

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## 1. INTRODUCTION

The urban spatial structure of cities and its relationship to the urban environment has recently been the subject of empirical, theoretical and policy research. This interest is a result that economic, social and environmental problems have become a worldwide concern for economists, as it witnessed by the development of many theories and policies aimed at driving the economy towards a sustainable urban development. This it becomes more significant even if the object of study and discussion is cities and their spatial configuration. In an attempt to give more light about what is the most sustainable spatial organization of cities, the literature has suggested the idea that polycentric structures generate important economic, environmental and social effects. This it may be explained by the considerably interest of urban planners and policy-makers for polycentricity since it has become one of the key components of the integrated spatial development strategy promoted by the European Spatial Development Perspective (ESDP). In fact, now polycentric spatial structures are considered a planning tool to enhance cities', metropolitan areas' and mega city-regions' competitiveness, social cohesion and environmental sustainability such as (Krätke, 2001; Bailey and Turok, 2001; Davoudi, 2003; Shaw and Sykes, 2004; Governa and Salone, 2005; Hoyler et al., 2008; Vandermotten, 2008 and; Veneri and Burgalassi, 2012) have studied.

In this sense, on the one hand, the urban economics literature have paid considerably attention on examining urban inequality at local scale (Wheeler, 2004; Wheeler, 2008; Glaeser, 2000; Glaeser et al., 2008; Glaeser et al., 2009 and; Lee et al., 2013) consistent with the idea of convergence studied among others by (Barro and Sala-I-Martin, 1991; Wheeler, 2004 and; Berry and Glaeser, 2005), due mainly to today most people are living in cities and their experience of inequality is shaped by their local and metropolitan environment, although in the last decades, the specialized literature has done a great deal of effort to investigate in detail the dynamics of urban inequality at national scale, across countries. Hence, this brings these studies which have focused on different spatial scales, to reach in several times on divergence findings because of the metropolitan or the local scale are capturing the population movement more properly rather than when the analysis has been carried out at national scale: *“the ready movement of people across space within a nation means that the inequality of a particular place is likely to reflect the selection of skilled and unskilled workers into that place. Easy mobility across city boundaries means that redistributive policies that would lead to a more equal society if applied at the national level may lead to disastrous results at city-level. City-specific redistribution may lead to an exodus of the wealthy and an influx of the poor that leaves the city impoverished”* compared to at local scale: *“paradoxically, local inequality is actually the inverse of area-level income segregation, holding national inequality constant, local inequality falls as people are stratified across space so that rich live with rich and poor live with poor”* (Glaeser et al., 2009:617-618).

Within this first line of research, to carried out the empirical analysis, the aforementioned studies related to urban inequality at local scale have contextualized their hypothesis to be tested into the theoretical and empirical framework based on the scope and the influence of agglomeration economies on wages and incomes in order to understand in-depth their benefits and costs as regards cities and metropolitan areas. Hence, the main contributions of (Lewis and Prescott, 1974; Carlino, 1985; Rauch, 1991; Carlino and Voith, 1992; Glaeser et al., 1992, 1995; Harris and Ioannides, 2000; Glaeser, 2000; Glaeser and Maré, 2001; Wheeler, 2001, 2006; Wheaton and Lewis, 2002; Fingleton, 2003, 2006; Glaeser and Saiz, 2003; Shapiro, 2005; Kim, 2006; Rice et al., 2006; Yankow, 2006; Combes et al., 2008, 2010; Di Addario and Patacchini, 2008; Graham and Kim, 2008; Melo and Graham, 2009; Glaeser and Gottlieb, 2009; Goetz et al., 2010; Graham et al., 2010; Glaeser and Resseger, 2010 and;

Glaeser et al., 2012) have attempt to investigate whether agglomeration economies next to other factors related to human capital and experience for example, exert a statistically significant effect on wage growth, hourly wage for individuals, median income family, per capita income and its subsequent growth and per capita property tax for example, because of its static and dynamic externalities: causes and consequences of urban inequality.

On the other hand, from urban economic theories suggest that urban spatial transformation from monocentric to polycentric structure could be able a great mechanism of mitigating agglomeration diseconomies that emerge in monocentric cities (Henderson and Slade, 1993; Fujita and Krugman, 1995; Sasaki and Mun, 1996; Henderson and Mitra, 1996; Henderson, 1997; Fujita et al., 1997, 1999 and; Henderson et al., 2000) and their disamenities such as crime and social conflict (Glaeser et al., 2008) that brings the rich population to live further from the central city (CBD). This issue is studied in the literature through analyzing the pairing urban centralization and income inequality by capturing the changes of urban density in cities and metropolitan areas (Wheeler, 2008). Thus, the literature reveals an inverse relationship between urban density and the degree of income inequality within metropolitan area which entails that as urban areas spread out, they become more and more segregated by incomes. In this sense, urban decentralization could represent the decisions of employed population and employers to expand their influence over more space due to the improvements related to transportation technology and infrastructure what has entail simultaneously an increment of commuting distances at the time that it has also been the most responsible for the rising disparity between cities, especially the decline of incomes in central cities relative to those of their suburban locations: *“as a metropolitan areas expand, the majority of both employment opportunities and relatively high-income households may shift from the central core to the periphery, thereby creating a widening income gap between these two areas. Over time, these differences may become more pronounced as the poor become increasingly isolated from productive interactions with wealthier neighbours”* (Wheeler, 2008:41-42).

Hence, in this theoretical framework of decentralization, if it occurs in a centralized way, then polycentricity may be emerged as one of the possible equilibrium that, once achieved, should structure the social equity of the system correctly: for example, proximity to sub-centres should affect wages (i.e. per capita income and its subsequent growth) in the same way that the central city of a metropolitan area (CBD) used to, albeit on a smaller spatial scale with the difference that now in polycentric structures due to the mitigation of diseconomies economies, urban amenities tend to be located in the centres that define this multi-centered spatial structure and consequently shaping a more balanced distribution across space because the wealthy population tend to locate their households in or close to them. However, to the best of our knowledge, investigating the relationship between urban structure and urban inequality through defining properly the urban structure at intra-metropolitan scale and testing their effects (defining the urban structure by means of the central city and the subcentres at the time that the agglomeration economies that emerge from them are considered) is a issue which has not been studied yet in the literature.

In this context, the aim of this paper is to determine whether the central city (CBD) and in particularly sub-centres (so, the nodes that define a polycentric spatial structure at intra-metropolitan scale) exert an influence on the causes and the consequences of urban inequality in the Barcelona Metropolitan Region, and if so, how it is this relationship in order to define future polices that enhance social equity. To do so, two research questions arise: a) what determines the degree of inequality across the municipalities of the Barcelona Metropolitan Region? and, b) what are the factors behind the inequality growth across these

municipalities?. The former question is addressed through using spatial econometric techniques that estimate if per capita income in 2008 (causes of urban inequality) is dependent on the past agglomeration economies that have emerged from CBD and sub-centres in 2001 correspondingly. The latter research question, is also studied through examining whether urbanization and localization economies that have emerged from CBD and sub-centres in the past, matters for the per capita income growth (consequences of urban inequality) between 2001 and 2008. To achieve both objectives, this paper has taken into account the distance to the central city (CBD) and the distance to urban sub-centres (main variables to define the urban spatial structure) as a proxy of the proximity (access to) to the agglomeration economies with metropolitan scope that arises from them. In addition, it has assessed the role of other relevant spatial variables and other non-spatial characteristics of the Barcelona Metropolitan Region: effects of agglomeration economies at local scale (population density), land use mix (balance), socioeconomic initial conditions, human capital externalities, age structure, urban amenities and geographical location of the municipalities within the metropolitan region. As a result, because of this paper investigates the dynamics of urban inequality at local scale through using per capita income and its subsequent growth, it is worth mentioning that the specialized literature has been suggested other dimensions of social equity, for example social conflict by means of criminality rates, poverty rates and racial composition. However, due to the lack of this data at local scale (municipalities) for the Barcelona Metropolitan Region, in our work we have to focus on per capita income as a proxy for analyzing the causes and the consequences of urban inequality.

Therefore, starting from previous contributions to this field of research, this paper tries to examine these effects by focusing on a intra-metropolitan perspective and on the influence that exert the nodes that define the polycentric structure (central city and sub-centres) what entails: a) a new perspective of empirical analysis (intra-urban) compared to the aforementioned current literature studies based on inter-urban or inter-regional scales (Wheeler, 2004 and; Glaeser et al., 2009) and, b) a properly definition of urban structure effects in relation with the research conducted at intra-urban scale (Glaeser et al., 2008; Wheeler, 2008 and; Lee et al., 2013). Hence, the first study examines change 90<sup>th</sup>-10<sup>th</sup> weekly wage differential and per capita income growth between 1970 and 1990 across 103, 220 and 226 U.S. MSA (metropolitan statistical areas) for each decade respectively. Next to this, Glaeser's work has focused on investigating the determinants of a) income growth between 1980 and 2000 across 258 U.S. MSA and, b) Gini coefficient of pretax income inequality in 1980, 2000 and 2006 across 258, 282 and 242 U.S. MSA correspondingly. Then, as regards the latter studies which are focused on intra-urban disparities, none of them have considered the effect of sub-centres. Thus, Glaeser's study examines the factors that are able to explain a) tract median household income in 2000 across 16 U.S. cities, b) tract household median income in 2000 across 8 U.S. cities and, c) income in 2000 across 109 U.S. MSA (metropolitan statistical areas) by considering the distance to the central city (CBD) within different distance rings (less than 3 miles, between 3 miles and 10 miles, and; more than 10 miles) and other factors related to accessibility to rail transit, MSA employment centralization and initial conditions of household income. While, Wheeler's study investigates whether population density as a proxy of urban structure (and urban decentralization) effects exert an statistically significant influence on a) variance of income for 359 U.S. metropolitan areas and, b) changes within and in between neighbourhood income during the period 1980 and 2000 across also 359 U.S. metropolitan areas. Lastly, Lee's study, analyses among several urban inequality indicators, the determinants of per capita income in 2009 and its growth between 1980 and 2009 across 533 municipalities of New Jersey State by considering population density and population growth as variables related to urban structure at local scale.

This leads to the second main contribution of this work. As the spatial scale is the municipality level and this paper is testing whether the municipalities identified as sub-centres exert an influence to foster per capita income and its subsequent growth, the results of this research could be useful in order to define future social equity policies for the Barcelona Metropolitan Region that reduce the urban inequality by means of for example, proposing new areas of urban development in these sub-centres or in their neighbour municipalities because of it entails a balance spatial distribution across the metropolitan region of nodes that guarantees high per capita income next to a positive prospective growth for its employed population, so promoting policies at local and metro level oriented to achieve co-operation and cohesion between municipalities (the central city of Barcelona, sub-centres and the rest of municipalities). In addition, that it also could entail a revisiting of the compact city concept: if sub-centres at intra-metropolitan scale are virtuous to enhance social metropolitan performance, because there is a more social balance spatial distribution, then promoting a set of compact cities formed by CBD and its surrounding sub-centres makes sense compared to the traditional concept of compact city which entails a reinforcement of monocentrism due to its policies are highly oriented to the central city or downtown. Finally, this paper contributes to conduct research to fill the lack of empirical research in these issues in the Barcelona Metropolitan Region. To the best of our knowledge at present, there are no studies in the literature which analyze the relationship between urban spatial structure and urban inequality.

However, the analysis of intra-urban scale requires a first step that is based on identifying the sub-centres that are within of this metropolitan area. To do so, is used the method to identify sub-centres proposed by the author of this work in (Masip, 2012a). This approach is suitable for identifying sub-centers that are within the bid-rent theoretical tradition based on the process of employment decentralization from a single and congested Central Business District (CBD) and also is suitable for the hierarchical and complex European urban systems where centers mostly emerged as a result of the integration or coalescence of pre-existing cities. In this way, Masip's approach takes into account the morphological and the functional characteristics of nodes (municipalities) according to the different dimensions that polycentricity is based on. In addition, the procedure is able to characterize the sub-centres that are “places to work” (employment sub-centers) and sub-centres that are “places to work and live” (urban sub-centers). That means distinguishing between those sub-centers that only attract workers (in-commuting flows) or retain their resident workers from those sub-centers that are able to attract flows and retain their resident employed population at the same time. In that sense, this brings to the current research more in-depth analysis about the influence of sub-centres on the costs of commuting according to its formation origin-nature.

The study is divided as follows. Section 2 presents a review of the literature on urban inequality at local scale by focusing on a) a briefly explanation of polycentric city formation from a social equity perspective, b) the scope and influence of agglomeration economies and their externalities on wages, c) the dimension of social equity and urban inequality on the basis of examining wage inequality distribution, d) a synthesise of the role of spatial and non-spatial characteristics and finally, e) addressing endogeneity in the estimation of agglomeration economies. Section 3 presents the study case, and defines its urban structure. Section 4 is devoted to test empirically the relationships between urban spatial structure by means of the central city (CBD) and sub-centres' influence (according to its different nature) and other spatial and non-spatial characteristics with per capita income in 2008 and its subsequent growth during the time period from 2001 to 2008. Section 5 sets out the main conclusions and further research steps. Finally, in the end of the paper is presented an appendix with more information related to the empirical work.

## 2. LITERATURE REVIEW

In this section is carried out a theoretical review of the still uncertainty and opened debate between agglomeration economies and social equity on the basis of wage and/or income distribution (levels and growth). In this way, we could contextualize the current debate between agglomeration and social equity and obviously it helps us to test empirically a new framework of analysis: the relationship between urban spatial structure (defined through the urbanization and localization economies that emerge from CBD -central business district- and sub-centres) and the causes and the consequences of social equity or urban inequality (defined by per capita income and per capita income growth) at intra-metropolitan scale. Hence, to do this theoretical analysis, firstly, a) is explained briefly, the process towards the formation of polycentric city to contextualize the next points of Section 2; secondly, b) is studied the influence of agglomeration economies on wages and/or incomes; thirdly, c) this issue is analyzed in a way to define social equity through understanding that wage or income inequality are the main responsible for urban inequality; then, d) are synthesized the role of spatial and non-spatial characteristics that exert a significant influence on the social equity of cities; and finally, e) is revised how the current studies in the literature have addressed the endogeneity problem in the estimation of agglomeration economies.

### 2.1. From monocentric city to polycentric city: a social equity perspective

One of the contributions of the monocentric-city model developed by (Alonso, 1964; Mills, 1967 and; Muth, 1969) is to give insight into the effect of income on household location. Two opposing forces are identified by the monocentric model. The former force, is related to consider that higher housing consumption of wealthy population means that they are more likely to be stronger attracted than the poor population by lower housing prices and rents in the suburbs. However, the latter force is referring with that rich households also have a high opportunity cost of time and thus a high commuting cost per mile. Hence, the rich value accessibility (and, so proximity) to the central business district (CBD) more than the poor. The literature on the basis of urban theory, reveal that the net influence (effect) of these forces hinges on the behavior of the ratio of commuting cost per mile (c) and housing consumption (h). If this ratio (c/h) increases with income, then the accessibility effect dominates, and the rich tend to live at central locations, but whether this ratio decreases with income, then the effect of higher housing consumption dominates, and the wealthy population tend to locate their households in the suburbs. This urban theory is consistent with the variety of location patterns observed in cities. For example, the aforementioned ratio tends to fall with income in the U.S. cities, while rising with income in Europe ones. Thus, high-income residents in U.S. urban areas tend to live in the suburbs (Glaeser et al., 2008), so far away from the central city, while this dynamic is completely inverse in Europe cities (Hohenberg and Lees, 1996). In this sense, the study of (Hohenberg and Lees, 1996:299) point out: “*Land-use succession, filtering, and a movable social geography are characteristic of American as well as of European cities. It is worth dwelling a moment on the differences between the two. In general, these processes proceeded more strongly and freely in the United States, since European cities were comparatively homogeneous in ethnic composition an their elites were more traditional in outlook and behavior. The rich were less apt to move their residence by choice. In the United States where social distinctions were less openly acknowledged though perhaps not less important than in Europe, locational choices and physical separation developed into crucial elements of the social process. The differences were only of degree perhaps, but the result was a reorganization of social geography: incomes rose with distance from the city center in America, whereas they typically fell in Europe*”.

Consequently, one of the explanations that the urban theory gives is that the location of different income groups across the space is linked to the spatial pattern of amenities in the cities and concludes that whether the center city has a strong amenity advantage over the suburbs, the rich are likely to live at central location, while if the center's amenity advantage is not stronger, so it is weak or negative, the wealthy population are likely to locate their residence place in the suburbs. In the context of this amenity competitive advantage, the urban theory also suggests that among different kinds of amenities, the historical ones are playing a significant role, linking with the previous given explanations of Hohenberg and Lees' work: Europe's longer history provides an obvious reason why its central cities contain more buildings and monuments of historical significance than do their U.S. counterparts. Many European cities were major metropolises at a time when much of the U.S. had not even been settled, and the legacy of urban development from this distant past provides an atmosphere in European city centers that appears to be highly valued by the residents. This is shown for example in the studies of (Glaeser, 2000 and; Glaeser et al., 2008) in which reveal, only in the case of older cities in U.S., a negative association between income (and its subsequent growth) and the distance to the central city (incomes falls as distance to the CBD increases).

However, another likely explanation that not rejects the previous one is the unfolding transformation of cities from monocentric structure pattern to a polycentric one. With the spread of the city and the development of new nodes (subcentres), a new model was developed of the locational tradeoff between centrality and travel costs, based on the earlier Bid Rent Models mentioned previously. In addition, the empirical studies confirm that population and employment densities fits more closely in this new urban model, defined by the urban economy literature as a multi-centered or polycentric city and which is shaped as a result of agglomerative forces and congestion forces (or between centripetal and centrifugal forces on the basis of the core-periphery theory) than in the monocentric ones. This is as a consequence of the emergence of job density peaks on the periphery of cities, and despite the improvements brought about in the monocentric city model by including for example the main transportation routes in the model, an increasing inability to explain intra-metropolitan patterns of density, commuting and location of households is detected back in the seventies, especially starting in the eighties and being a reality at present.

Thus, from a social perspective, this new urban model based on a multi-centered city that has emerged of the unstable equilibrium between these two pair of forces could be able a great mechanism of mitigating agglomeration diseconomies that arise in monocentric cities and consequently its implied disamenities such as crime and social conflict that brings the rich population to live further and further from the city center and have to commute greater and greater distances: in a city with multiple employment centres, firms and especially population from a social perspective, in sub-centres can avoid the external costs of central location while still benefiting from agglomeration economies and consequently amenities could emerge in these centers and the aforementioned disamenities such as crime, social conflict and racial or social segregation is less likely to occurring. Therefore, polycentricity may be emerged as one of the possible equilibrium that, once achieved, should structure the social equity of the system correctly: for example, proximity to sub-centres should affect wages (i.e. per capita income and its subsequent growth) in the same way that the central city of a metropolitan area (CBD) used to, albeit on a smaller spatial scale with the difference that now in polycentric structures due to the mitigation of diseconomies economies, urban amenities tend to be located in the centres that define this multi-centered spatial structure and consequently shaping a more balanced distribution across space because the wealthy population tend to locate their households in or close to them.



## 2.2. Scope and influence of agglomeration economies on wages: an extension of a previous work

In this Section 2.2, we attempt to extend the work carried out by (Masip, 2012b) as regards the literature revision focusing on the effects of agglomeration economies on wages in which it has explained in detail the contributions of (Rauch, 1991; Glaeser et al., 1992, 1995; Harris and Ioannides, 2000; Glaeser and Maré, 2001; Combes et al., 2008, 2010; Melo and Graham, 2009; Glaeser and Gottlieb, 2009; Goetz et al., 2010 and; Graham et al., 2010).

In this context, the research conducted by (Lewis and Prescott, 1974) investigates the connection across 104 U.S. SMSAs (standard metropolitan statistical areas) between wages rates and city size by estimating regression models<sup>2</sup> through using OLS (ordinary least squares) techniques and by considering a) the whole economy (aggregated wages) and, b) 19 different individual industry sectors<sup>3</sup> in 1963. Hence, the results that Lewis and Prescott's study reaches on as regards the former analysis are: a) all coefficients are highly significant (population, employment per establishment, capital-labor ratio and, distance to major regional market) and positively associated with wages, although the variables measuring the characteristics of manufacturing firms are of greater importance than the variables as regards city size's effects (population) and agglomeration economies' effects that emerge from the proximity (access) to the major regional market, as a result of, b) the elasticity values of population ( $N_i$ ) and distance to the major market ( $D_i$ ) are 0,00938 and -0,9756 respectively, in comparison with the elasticities of ( $S_i$ ) and ( $K_i/L_i$ ) which are 1,251 and 119,5 correspondingly. Next to this, (Lewis and Prescott, 1974:33) point out the following findings related to the individual industrial sectors analysis: a) the signs of the coefficients are generally consistent with the aggregated results, although with some exceptions: b1) population (city scale) is negatively associated with wage rates in the cases of textile mill products industry and professional instruments industry, b2) distance (less proximity and access to major regional market) is positively associated with wage rates in the cases of lumber, wood sector and petroleum refining industry and, b3) small firm sizes (employment per establishment) as regards leather products, textile mills products and furniture sectors foster higher wage rates; next to this, this latter empirical analysis reveals that, c) scale's effects through population size of SMSAs do not exert the most prominent influence on wage rates and, that this role is played firstly by the capital-labor ratio and secondly by employment per establishment respectively.

After Lewis and Prescott's study, it is worth mentioning the pioneer work carried out by (Carlino, 1985). Its study develops an empirical model<sup>4</sup> which is estimated through using

<sup>2</sup> The baseline regression model that Lewis and Prescott's study proposes is the following one:  $w_i = f(N_i, S_i, K_i/L_i, D_i)$ , where the dependent variable is the wages rate ( $w_i$ ) measured as the annual production worker wages divided by the number of production workers in 1963. Next to this, the independent variables are: 1) POPULATION ( $N_i$ ) which is calculated as the population of Standard Metropolitan Statistical Area (SMSA) in 1960, 2) EMPLOYMENT PER ESTABLISHMENT ( $S_i$ ) which is measured as the number of production workers divided by the number of establishments with payroll in 1963, 3) CAPITAL/LABOR RATIO ( $K_i/L_i$ ) which is calculated as the value added by manufacturing minus payrolls to all employees, divided by production worker man-hours in 1963 and finally, 4) DISTANCE ( $D_i$ ) which is the highway mileage from the SMSA to major regional market center.

<sup>3</sup> The 19 industrial sectors that the study carried out by (Lewis and Prescott, 1974) take into account are: chemicals and allied (28), paper and allied (26), rubber products (30), food (20), leather products (31), fabricated metals (34), textile (22), stone, clay and glass (32), primary metals (33), printing and publishing (27), transport equipment (37), electrical machinery (36), furniture and fixtures (25), machinery (35), lumber and wood (24), professional instruments (38), apparel and other (23), petroleum refining (29) and, miscellaneous (39).

<sup>4</sup> The baseline of the empirical model that (Carlino, 1985) proposes, takes the following form:  $\log W_{ij} = \log A + \beta \log Q_{ij} + \gamma \log L_{ij} + \log U_{ij}$ , where the dependent variable is ( $W_{ij}$ ) which is measured as the ratio between the

OLS (ordinary least squares) techniques and, which attempts to analyze the connection between agglomeration economies' effects and wages across 80 U.S. SMSAs between the period of 1957 and 1977. In this sense, the main findings that (Carlino, 1985:25) reaches on are: a) population is positively associated with wages until to a certain extent in which because of congestion costs and negative agglomeration externalities this connection turn into being a negative one, this happens at the threshold of 8 million people in a given SMSA and, b) labour and output also exert a positive and statistically significant effect on wages.

An extension of Carlino's work, is the study of (Carlino and Voith, 1992) in which examines the determinants of aggregate productivity at the state level, across 48 U.S. states between 1967 and 1986 through estimating a model which attempts to account for variation in aggregate wages and manufacturing wages resulting from state-to-state differences in industry mix, labor force characteristics, public investment in infrastructure and metropolitan structure. To do so, its proposed empirical model<sup>5</sup> is estimated through using a) OLS (ordinary least squares), b) LSDV (least squares dummy variable) model and, c) GLS (generalized least squares) methods<sup>6</sup> at the time that state differences in wages are modeled as a Hicks-neutral shifter term following an aggregate production function framework. Thus, the results that (Carlino and Voith, 1992:604-606) reveal as regards the determinants of aggregated wages across U.S. states are: a) wages are positively associated with a more educated labor force (with an elasticity value of 0,012) but it is not significantly affected by the degree of unionization (although, this connection is positive), b) infrastructure as proxied by highway density is positively related to wages (with an elasticity of 1,008), c) time or technical

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total manufacturing payroll in the (i) (th) SMSA in period (j) and, all manufacturing employees in the (i) (th) SMSA in period (j). Next to this, the independent variables are: 1) OUTPUT ( $Q_{ij}$ ) which is calculated as the ratio between total real value added by manufacturing in the (i) (th) SMSA in period (j) and the total number of manufacturing establishments in (i) for the (j) (th) time period, and 2) LABOR ( $L_{ij}$ ) which is measured as the ratio between all manufacturing employees in (i) at time (j) and, the total number of manufacturing establishments in (i) for the (j) (th) time period. At this point, (Carlino, 1985) introduces in the model a quadratic form of SMSA population, and consequently the model to be estimated takes the following form:  $\ln W_{it} + \ln L_{it} = \ln A_1 + \alpha_1 P_{it} + \alpha_2 P_{it}^2 + \beta \ln Q_{it} + h_0(1 - \beta) \ln L_{it} + h_1(1 - \beta) t \ln L_{it}$  where ( $P_{it}$ ) is the population within each SMSA,  $i=1 \dots 8$  and,  $t=1 \dots 20$ .

<sup>5</sup> The baseline model that (Carlino and Voith, 1992) define is:  $\ln W_{it} = \beta_0 + \sum_{k=1}^K \beta_k X_{kit} + \theta \ln Q_{it} + \gamma \ln L_{it} + \vartheta_i + v_{it}$ , where ( $v_{it}$ ) is the random error terms; ( $\vartheta_i$ ) is a fixed effects and estimates a separate intercept for each 48 considered state and, ( $W_{it}$ ) is the dependent variable which is the average wage bill in real terms, so nominal wages are converted to real terms by utilizing the national producer price index (PPI). Next to this, ( $X_{kit}$ ) is a vector of proxy variables (independent variables) which are based on: 1) EDUCATIONAL ATTAINMENT ( $E_i$ ) which is measured as the percent of workers with 12 or more years in 1980, 2) PERCENT UNIONIZATION ( $U_i$ ) which is calculated as the percent of employees in non-agricultural establishments in 1970 to capture the labor characteristics, 3) HIGHWAY DENSITY ( $I_i$ ) which is measured as total primary Federal-Aid Highway system miles per square mile of land area in 1980 to measure the effects of state infrastructure, 4) TIME INDEX ( $T_i$ ) which is employed to capture the effects of Hick-neutral technical progress on productivity, 5) DUMMY VARIABLE ( $Z_i$ ) which is utilized to capture the effects of the energy shock years (1973-1978) on state productivity, 6) PERCENT STATE'S POPULATION IN METROPOLITAN AREAS ( $P_{it}$ ) to capture the effect of agglomeration economies, 7) PERCENT STATE'S POPULATION IN METROPOLITAN AREAS ( $P_{it}^2$ ) in a square form in order to capture the effects of agglomeration diseconomies associated with congestion and, 8) STATE'S INDUSTRIAL STRUCTURE ( $S_{jit}$ ) which is measured as the percent share of total GSP (gross state product) accounted for by the jth one-digit industry (agriculture, mining, construction, public utilities, wholesale and retail trade, FIRE, services and; government) in state (i) at time (t). Finally, ( $Q_{it}$ ) and ( $L_{it}$ ) are measured by real GSP (gross state product) and employment in the ith state for time (t) respectively. Consequently, the regression model that (Carlino and Voith, 1992) estimate is:  $\ln W_{it} = \beta_0 + \beta_1 E_i + \beta_2 U_i + \beta_3 I_i + \beta_4 T_{it} + \beta_5 Z_{it} + \beta_6 P_{it} + \beta_7 P_{it}^2 + \sum_{j=1}^9 \beta_j + S_{7jit} + \theta \ln Q_{it} + \gamma \ln L_{it} + \vartheta_i + v_{it}$ .

<sup>6</sup> After being estimated its proposed regression model by using a) OLS, b) LSDV and, c) GLS; the work carried out by (Carlino and Voith, 1992) conclude that the regression model estimated by using GLS techniques is the model which is more efficient because of GLS estimation allows the inclusion of time-invariant variables.

progress does not exert a statistically significant effect on wages, d) the coefficient of the variable that capture the energy shock's effect is negatively and statistically significant associated with state's wages (with an elasticity value of -0,030), e) percent urban and percent urban square variables present the expected signs and both of them are statistically significant, so positively and negatively related to state's wages respectively with an elasticities of 1,713 and -1,692 correspondingly and, f) state's wages depending on its industrial mix: all sectors foster state's wages with the exception of mining and FIRE and government sectors which its effect is not statistically significant at the time that the connection of the first sector related to state's wages is negative, while as regards the other two sectors is positive. Next to this, related to the determinants of manufacture wages, (Carlino and Voith, 1992:613) point out that: a) education attainment is the only variable which has similar significant results compared to the previous aggregate wage model: statistically significant and positive connection to aggregated state's wages and consequently, b) highway density, percent urban, and, percent urban square do not exert a significant effect, although these variables present the expected sign. In conclusion, Carlino and Voith's work contribute to the literature in the sense that its study has proved that state's industrial mix, infrastructure, education level and, metropolitan structure all affect aggregated state's wages.

In a similar vein, (Graham, 2000) attempts to identify the factors underpinning spatial variation in manufacturing wages in Britain at county level at two time points, in 1984 and in 1991, through examining the extent to which it is determined by a) spatial externalities arising from the nature of the environment and by, b) other geographically (counties) variable characteristics. Thus, to test it empirically, Graham's study defines an empirical model<sup>7</sup> in which its dependent variable is defined as wage rates in 1984 and in 1991 provided by Annual Census of Production (ACOP) data and, which is estimated through using OLS (ordinary least squares) techniques and LSDV (least squares dummy variable) methods. Consequently, the results that (Graham, 2000:336-338) reaches on testing the hypothesis related to 1) the nature of spatial external effects on manufacturing wage rates and, 2) there is a prominent role of other 'non-environmental' factors including capital-to-labour ratios, economies of scale, industrial mix, and labour force characteristics, are: a) the locational variables appear to have quite strong influences on wage rates: on the one hand, there are externalities arising from the scale of the immediate environment with a positive coefficient of 0,764 in 1984 and 0,378 in 1991 indicating that urban scale of counties is positively associated with the manufacturing wage rates; on the other hand, there is a fairly consistent spatial effect as regards municipalities in London because of the their estimated coefficients are 0,291 for 1984 and 0,153 for 1991, significant at the 1% and 10% level respectively, what implies that the wage rate in London's manufacturing, is higher than would be predicted by the relationships determined for the counties generally; next to this, b) other effects associated with location externalities are either of very small important or are statistically insignificant, this is the case

<sup>7</sup> The wage equation that (Graham, 2000:332) estimates at county level is the following one:  $\ln w = \sum_n \beta_\delta \delta_n + \lambda \ln Y + \gamma \ln L + \gamma_E \ln E + \gamma_{EE} (\ln E)^2 + \gamma_C \ln C + \gamma_{ED} (\sum_j E_j / d_{ij}) + \gamma_{CD} \ln (\sum_j C_j / d_{ij}) + \delta_L DLON + \delta_M DMETS + \beta_{ST} \ln STRUCT + \beta_{SK} \ln SKILL + \beta_P \ln PART + \mu$ , where (Y) and (L) are the output level and labour input correspondingly. Next to this, the other determinants are: 1) E is total county employment in (i), 2) C is a measure of urban concentration, the density of total employment in (i), and ( $d_{ij}$ ) is the distance between counties (i) and (j), 3) DLON and 4) DMETS are dummy variables for London and the metropolitan counties respectively, 5) STRUCT is a variable to control for the structure of industry and which is constructed from data defined at the two-digit class level of the 1981 SIC where there are 21 manufacturing industries, 6) SKILL captures the quality of labour and which is measured as the degree of skills in manufacturing proxied by taking the proportion of non-manual workers employed and finally, 7) PART a variable that also capture the quality of labour as 6) and which is calculated in this case, as the extent to which part-time work is used in industry through measuring the proportion of part-time workers.

for example of the concentration variable (total density of employment) which their estimated coefficients are -0,018 for 1984 and -0,009 for 1991 at the time that it is only significant at 10% level for 1984, c) the industrial structure variable has a strong effect in creating spatial variation in the marginal product of labor, with estimated elasticities of 0,839 for 1984 and 0,898 in 1991 correspondingly, d) the level of skill in industry is positively associated with the wage rates with an elasticities values of 0,276 for 1984 and 0,252 for 1991 respectively and finally, e) there is no significant influence as regards part-time employee variable on wage rate at county level in 1984 and in 1991. Thus, (Graham, 2000:338) concludes that it seems that at the county level, no real systemic evidence of spatial external effects on manufacturing wage rates and as a result, that the specialized nature of county manufacturing rather than any powerful spatial external effect, are the main factors underpinning spatial variation between 1984 and 1991 in manufacturing wage rates in Britain.

In its turn, the work carried out by (Wheeler, 2001) develops an empirical model that formalizes the notion and demonstrates that not only local market size is positively associated with average productivity, but also it generates greater between-skill-group wage inequality (wage inequality) and a higher expected return to skill acquisition (return to skill) for samples of counties and metropolitan areas in the United States by using data from the 1980 at 1% metro sample of the Integrated Public Use Microdata Series. Thus, the empirical model that (Wheeler, 2001:889) estimates is based on, 1) defining as a dependent variable the logarithm of hourly wages, 2) constructing as explanatory variables, a vector of personal covariates (e.g. education, experience, gender, etc...) and a vector of characteristics of metropolitan area (e.g. average metropolitan area years of education, average metropolitan area experience, logarithm of resident population, etc...) and, 3) using OLS (ordinary least squares) techniques for estimating the regression model<sup>8</sup>. The results that (Wheeler, 2001:892) reaches on as regards wage inequality, are: a) there is a significantly positive premium associated with the resident population of an individual's metropolitan area: *“doubling of population corresponds to a 2,7% increase in a worker's hourly wage on average”*, b) local market size premium seems to increase with years of schooling completed: *“for workers at the top end of the educational distribution, a doubling of resident population is associated with a 4% increase in hourly wages, on average”* and, *“workers with 13-15 years of education and those with 9-12 years exhibit smaller gains: 3% and 2%, respectively. Among workers at the bottom end of the distribution, by contrast, the estimated partial correlation is not significantly different from zero”*, c) education and experience are positively significant related to wages, meaning that doubling education and experience corresponds to a 5% and 4% increase in a worker's hourly wage on average, although the maximum effect of education and education occur between 9 and 12 years of schooling (the increment on wages is around 7%) and above 16 years of schooling (the increment on wages is 5% in this case) correspondingly, d) a certain

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<sup>8</sup> The model that (Wheeler, 2001) defines takes the following form:  $w_{ij} = \alpha + \beta x_{ij} + \gamma z_j + \epsilon_{ij}$ , where ( $w_{ij}$ ) is the logarithm hourly wage of worker (i) who works in metropolitan area (j), ( $x_{ij}$ ) is a vector of personal covariates, ( $z_j$ ) is a vector of characteristics of metropolitan area (j), and ( $\epsilon_{ij}$ ) is an individual-specific residual. Specifically, the independent variables are: as regards vector of personal covariates, 1) education, 2) experience, 3) experience squares, 4) disables, 5) married, 6) in school, 7) female, 8) race (white=1), 9) female\*experience, 10) female\*experience squared, 11) female\*race, 12) female\*married, 13) female\*number of children, 14) professional or managerial, 15) technical or sales, 16) service, 17) craft and, 18) operator or laborer; next to this as regards a vector of metropolitan characteristics, 19) average MSA (metropolitan statistical area) education, 20) average MSA experience and, 21) logarithm of resident population. Finally, (Wheeler, 2001) apart from including these aforementioned independent variables, its study also includes 8 census division dummies. Next to this, the previous baseline regression model is estimated through considering five different individual samples: 1) all individuals, 2) individuals above 16 years of schooling, 3) individuals between 13-15 years of schooling, 4) individuals between 9-12 years of schooling and, 5) individuals between 0-8 years of schooling.

level of experience (experience square) its influence on wages is negatively correlated, although its negative effect is quite small, ranging from -0,05% to -0,1%, e) married and white workers are positively associated with worker's hourly wage and finally, f) high-order occupations such as professional or managerial workers, exert a greater positively influence on wages rather than low-order occupations such as operator or laborer. Consequently, the main contribution of Wheeler's study is that larger markets generate more stratified matches, such as areas will tend to allocate high-skill workers to more productive employers, leaving low-skill workers in less productive positions and a result, the overall effect boosts wages of the former areas relative to those of the latter ones.

From a different perspective, the research conducted by (Wheaton and Lewis, 2002) attempts to examine the effects of agglomeration economies (occupation concentration, occupation specialization, industrial employment specialization and industrial employment concentration) as well as the influence of individual characteristics (e.g. female, single, student etc...) on wages by using data comes from 1990 U.S. Census on the basis of a sample which consist of 400.000 individuals (males and females aged between 16 and 65 years) living in 220 U.S. metropolitan areas, 424 occupational categories and 77 industrial SIC groups. In this sense, the empirical model that (Wheaton and Lewis, 2002) define is based on, 1) defining as a dependent variable logarithm of hourly wages, 2) constructing as explanatory variables a vector of individual characteristics, a vector of occupation characteristics and a vector of industrial determinants and, 3) using OLS (ordinary least squares) techniques and fixed effects (metropolitan area, occupation, industry and demographic fixed effects) for estimating the regression model<sup>9</sup>. Hence, the results that (Wheaton and Lewis, 2002:552) reveal are: a) occupational specialization varies across 220 Metropolitan Statistical Areas (MSA) from 0 to 7%, what this range generates a 23% increase in hourly wages, b) industrial specialization ranges across 220 MSA and 77 SIC industries from 0 to 68% what implies a prominent 30% increase in wages, c) the occupational and industrial concentration are 0 to 46% and 0 to 41% respectively and as a consequence, these percentages entail somewhat smaller increment, around 12% and 16% increases in hourly wages correspondingly, and finally, d) establishment specialization and concentration are negatively associated with hourly wages: *“when there is high establishment specialization/concentration, there are more firms*

<sup>9</sup> The regression model that (Wheaton and Lewis, 2002:549) define, is the following one:  $\ln(w_i) = \alpha + X_i B + Z_{jl} \Delta + Y_{kl} \Gamma + \phi_k + \psi_l + \varepsilon_i$ , where ( $w_i$ ) is the hourly wage which is estimated by dividing total wage and salary income by the product of weeks workers and usual hours worked per week, (i) indexes individuals, (j) refers to an individual's occupation, (k) refers to an individual's industry, (l) refers to an individuals' MSA (metropolitan statistical area), ( $X_i$ ) is individual specific characteristics, ( $Y_{kl}$ ) is industry specialization and concentration (employment and establishments), and ( $Z_{jl}$ ) is occupation specialization and concentration. Thus, according to (Wheaton and Lewis, 2002), the vector of individual specific characteristics ( $X_i$ ) include the following variables: 1) age, 2) age (square), 3) less than high school, 4) 1-3 years of college, 5) more than 4 years of college, 6) age\*less than high school, 7) age\*1-3 years of college, 8) age\*more than 4 years of college, 9) age (square)\*less than high school, 10) age (square)\*1-3 years of college, 11) age (square)\*more than 4 years of college, 12) female\*less than high school, 13) female\*1-3 years of college, 14) female\*more than 4 years of college, 15) female\*age\*less than high school, 16) female\*age\*high school, 17) female\*age\*1-3 years of college, 18) female\*age\*more than 4 years of college, 19) female\*age (squared)\*less than high school, 20) female\*age (squared)\*high school, 21) female\*age (squared)\*1-3 years of college, 22) female\*age (squared)\*more than 4 years of college, 23) female dummy, 24) black dummy, 25) single dummy, 26) student dummy, 27) veteran dummy, 28) single female dummy and finally, 29) black female dummy. Next to this, related to specialization and concentration variables, (Wheaton and Lewis, 2002) define: a) occupation concentration which is calculated as the number of workers in a MSA/occupation divided by the total national workers in that occupation, b) occupation specialization which is measured as the MSA/occupation number of workers divided by total MSA labor force and finally, c) industry employment specialization and concentration as well as industry establishment specialization and concentration are calculated in the same way as a) occupation concentration and, b) occupation specialization respectively.

*employing the same number of workers in a portion of the labor market, and firms size is hence lower. The result is that wages are lower, and this suggests that monopsony is not a problem in local labor markets*". As a consequence, (Wheaton and Lewis, 2002) conclude that a) in general workers in cities with a larger share of national or metropolitan employment in their same occupation or industry earn higher wages what imply that employment shows a strong localization economies, and there also strong gains to specialization, while there is a little evidence of economic diversity or urbanization economies and, b) the negative effect of establishment specialization and concentration reveal the evidence of increasing returns at the firm or establishment level –independent- of agglomeration in the local labour market.

In this context, another relevant study as regards the connection between wages and agglomeration economies is the work carried out by (Fingleton, 2003). Its study makes evidence that wage rate variation among 408 local areas (unitary authority and local authority districts) of Great Britain are significantly positively related to employment density, and its study briefly concludes that: presence of increasing returns deriving from more varied producer services in denser areas, controlling for the effect on wages of good access to an efficient workforce, either locally or as a result of in-commuting. Therefore, to test it empirically the aforementioned conclusions, Fingleton's study defines a regression model<sup>10</sup> estimated through two stage least squares (TSLS) with instruments variables<sup>11</sup> which starts from a Cobb-Douglas production function, in which the dependent variable is gross weekly pay for 1999 and 2000 and, the determinants are related to: 1) employment density, 2) schooling, 3) technical knowledge and, 4) spillover, neighbours' effect. The results that (Fingleton, 2003:731) points out are: a) there are positive and statistically significant effects because of increasing return to employment density (with an elasticity value of 0,016446), and a significant relationship between wage rates and labour efficiency levels within local areas as reflected by educational attainment rates (with an elasticity of 0,292881) and the concentration of employment in computing and research and development (with an elasticity of 0,050397), b) wages are also significantly (with an elasticity value of 0,001373) related to wage rates in other 'nearby' or 'neighbour' areas, which is interpreted as an effect operation via the dependence of an area's labour efficiency on efficiency levels of other areas and which is caused by commuting and, c) the omitted variables' effect is very significantly different from zero, implying that there is a range of other external economies and omitted variables that while unknown in detail, are at least embodied in the regression model of wages in an indirect way and this is justified by the fact that they do have a significant effect (with an elasticity value of 0,776197). These results are consistent with the main conclusion that arises from this study, mentioned previously but also reveals that without commuting, wages and productivity in central cities would be much lower, and highlights the comparatively low

<sup>10</sup> The baseline regression model that (Fingleton, 2003:722) takes the following functional form:  $\ln(w) = k_2 + \rho W \ln(w) - \rho W k_1 + (\gamma - 1)(\ln(E)) + \alpha_1 H + \alpha_2 T + v$ ; where (w) is wage rates (gross weekly pay) by unitary authority and local authority districts in Great Britain; (E) is employment density which is calculated as the total employee level divided by its area in square km; (H) refers to schooling which is calculated as the proportions of pupils in each area achieving two or more A level qualifications in 1991; (T) is the technical knowledge which is measured as the location quotient for each area giving the workforce specialization in computing and related activities (SIC 72) and in research and development (SIC 73); ( $k_2$ ) is a constant and ( $Wk_1$ ) is a variable that depends on the unknown values. From this equation, (Fingleton, 2003) defines this another equation which uses as the final equation to be estimated:  $\ln(w) = k_2 + \rho W \ln(w) + (\gamma - 1)(\ln(E)) - \rho W \ln(E) + \alpha_1 H + \alpha_2 T + \alpha_3 r_{-1} v$ , where is assumed that the net outcome of omitting sectoral composition and externalities is given by estimated 1999 errors that are represented by ( $r_{-1}$ ).

<sup>11</sup> In accordance with the instruments variables that (Fingleton, 2003) uses the method based on the three group approach in which the instrument variable takes values of 1, 0 or -1 according to if employment density is in the top, middle or bottom third of its ranking, which ranged from 1, the area with the lowest employment density, up to 408 (there are 408 local authority areas).

income levels of many inner city residents. Consequently, this work may bring some new lights related to what kind of efficient policies should be applied in cities. In this sense, perhaps policy should focus even more on raising skills levels in central cities, possibly by training unskilled workers and by promoting residential development that would appeal to workers with appropriate skills, so as to satisfy a larger portion of the demand that evidently exists and reduce the need for in-commuting.

An extension of the work carried out by (Fingleton, 2003) is the research conducted by the same author, in which investigates what theory based on exploring the spatial concentration of economic activity, namely new economic geographic (NEG) theory which emphasizes varying market potential and, urban economic (UE) theory in which the main emphasis is on producer service linkages could explain better the rate variation across small regions of Great Britain. To do so, (Fingleton, 2006) estimates through using a) two-step least squares (2SLS) and, b) spatial lag model with instruments variables<sup>12</sup>, an NEG wage equation<sup>13</sup> and compares the results with the alternative but related urban economics (UE) model<sup>14</sup> which denies any role for market potential a primary cause of wage variation to the pecuniary externalities deriving from the presence of service sector linkages which are particularly evident in urban areas, so that in this UE set-up wages increase with the density of productive activity. The results that (Fingleton, 2006:19) reaches on as regards NEG wage model are: a) market potential variable presents a positive and significant estimated coefficient (0,1506) and consequently it fosters wage rate variations; although when it is not controlled for labour efficiency variables (local schooling, local technical knowledge and commuting) this market potential's effect on wages is considerably higher, entailing an estimated coefficient of 0,57623, b) the estimated coefficient of commuting indicator is positively related to wages, implying an elasticity value of 0,0174, c) the negative coefficient on schooling with an elasticity of -0,0008 is consistent with its definition as a lack of qualification and finally, d) technical knowledge variable is positively and statistically significant related to wage rate variations with an elasticity value of 0,0458. Next to this, as regards UE wage model, (Fingleton, 2006:20) points out that: a) the quantitative impact of employment density is moderated somewhat with the introduction of the significant commuting term: without considering commuting influence the elasticity of employment density is 0,0486, while by controlling for the commuting term, then this elasticity decreases to 0,0139 and, b) the labour efficiency level within each local area is a significant factor with both variables, schooling (human capital) and technical knowledge correctly signed and significant; presenting an elasticity values of -0,0017 and 0,0526 correspondingly. As the results are not conclusive, (Fingleton, 2006) estimate an artificial nesting model<sup>15</sup> (ANM) to test empirically both

<sup>12</sup> The methodology that (Fingleton, 2006) defines in order to instruments variables estimation is the same as the work carried out by (Fingleton, 2003) has suggested previously (see, cite 11).

<sup>13</sup> The NEG wage equation that (Fingleton, 2006) proposes is the following one:  $lnw^0 = \rho W lnw^0 + \alpha_1(lnP - \rho W lnP) + b_0 + b_1S + b_2T + \xi$ , where (w) are wages on the basis of considering gross weekly pay for male and female full time workers through using data provided by the Office for National Statistics' New Earnings Survey in 2000; (P) refers to market potential variable; (S) is the percentage of residents with no qualifications as given by the UK's 2001 Census; (T) is approximated by the relative concentration of employees in the computing (SIC 72) and research and development sectors (SIC 73), so this variable is calculated according to (Fingleton, 2006:11) the location quotient for each area giving the workforce specialization in the aforementioned sectors; and finally,  $(\rho W lnw^0)$  refers to commuting influence on wage rates.

<sup>14</sup> The UE wage equation that (Fingleton, 2006) define is:  $lnw^0 = \rho W lnw^0 + (\gamma - 1)(lnE - \rho W lnE) + c_0 + c_1S + c_2T + \psi$ , where in this case,  $((\gamma - 1)(lnE - \rho W lnE))$  refers to the employment density (which is measured as the total employment level per square kilometer) influence on wage rates and, the others determinants are explained in the previous cite 13.

<sup>15</sup> The ANM model that (Fingleton, 2006) proposes to estimate is:  $lnw^0 = \rho W lnw^0 + d_0[(I - \rho W)lnE] + d_1[(I - \rho W)lnP] + g_0 + g_1S + g_2T + \xi$ , where with the terms of  $(d_0[(I - \rho W)lnE])$  and,  $(d_1[(I - \rho W)lnP])$ ;

hypothesis of NEG and UE theories in one wage equation simultaneously. The results that (Fingleton, 2006:21-22) reveals in this case are clearly conclusive: a) labour efficiency variables: schooling, technical knowledge and commuting, show the expected sign and its influence on wage rate variation is statistically significant, with elasticities of -0,0018; 0,0505 and; 0,0017 respectively, b) the estimated coefficient of employment density is statistically significant and it is similar as the previous two estimated models (0,0139); however, c) the artificial nesting model by addressing spatial correlation, reveal that market potential does not exert an statistically significant effect on wages (its t-value is 0,55). Consequently the main contribution of Fingleton's study is related to the fact that UE theory (with employment density) has more explanatory power rather than the NEG theory (which emphasizes market potential) what brings to the conclusion that market potential alone will not explain local wage variations and that modifications allowing for labour efficiency variations are necessary.

Another meaningful work which attempt to study in-depth the relationship between wages and agglomeration economies, is the research conducted by (Glaeser and Saiz, 2003). By starting from considering the three hypotheses of a) consumer city, b) informational city and, c) reinvention city; this study defines a set of regression models<sup>16</sup> in order to investigate, 1) the determinants of income growth<sup>17</sup> across 918 U.S. MSA (metropolitan statistical areas), 2) the connection between wage and human capital<sup>18</sup> considering workers as unit of observation, 3) the relationship between real wage and human capital<sup>19</sup>, but now taking into account U.S. MSA as spatial unit and, 4) the corroboration of the reinvention hypothesis<sup>20</sup>. The results that

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Fingleton's study assumes that wage rates depend not only on market potential and labour efficiency, but also on the market services input linkages (density of employment) in an area, anticipating the further development of formal theory combining these two separate perspectives.

<sup>16</sup> The baseline regression model that (Glaeser and Saiz, 2003) define in order to examine wage rates is the following one:  $\log(\widehat{W}_{j,t+1}/\widehat{W}_{j,t}) = I^W + \sum_k \left( \delta_A^k \frac{\gamma}{\eta} - \delta_C^k \frac{1-\alpha-\beta}{\eta} \right) X_{j,t}^k + \mu_{j,t}^W$ , where ( $I^W$ ) is the intercept terms that is constant across cities, ( $\mu_{j,t}^W$ ) is an error terms and, ( $X_{j,t}^k$ ) are city-specific characteristics as of time (t), for example, the share of skilled workers.

<sup>17</sup> The first set of regression models proposed by (Glaeser and Saiz, 2003) are based on estimating through using OLS (ordinary least squares) techniques and fixed effects (year, region, state and MSA –metropolitan statistical area) the following two samples: 1) the dependent variable is the change logarithm of average MSA between 1970 and 2000 and, 2) the dependent variable is the change logarithm of average city family income. Next to this the explanatory variables used by Glaeser and Saiz's work in both model samples are: 1) share of population above 25 years with bachelor's degree (t-10), 2) logarithm of average family income (t-10), 3) unemployment rate (t-10), 4) share of high school drop outs as regards population above 25 years (t-10) and, 4) logarithm of college per capita (t-10).

<sup>18</sup> The second type of regression model defined by (Glaeser and Saiz, 2003) is based on estimating by using OLS (ordinary least squares) techniques and fixed effects (MSA, year) the next regression sample: 1) the dependent variable is the logarithm IPUMS wage which is obtained on the basis of a sample data focused on 1026867 workers between the period 1970 and 2000. Next to this, the determinants are: 1) share of bachelors at t-10\*dummy 1980, 2) share of bachelors at t-10\*1990 and, 3) share of bachelors at t-10\*2000.

<sup>19</sup> The third set of regression models suggested by (Glaeser and Saiz, 2003) are based on estimating through using OLS (ordinary least squares) techniques and fixed effects (decade and region) the following three models: 1) the dependent variable is the change logarithm of average wages divided by accra prices between 1970 and 2000, 2) the dependent variable is the change logarithm of average manufacture wages divided by accra prices during the period 1970 and 2000 and, 3) the dependent variable is the change logarithm of IPUMS adjusted wages divided by accra prices between the period 1970 and 2000. In this case, (Glaeser and Saiz, 2003) construct the following explanatory variables: 1) share of bachelor's (above 25 years) at t-10, 2) logarithm of population at t.10, 3) logarithm of average heating degree days between 1961 and 1990, 4) logarithm of average annual precipitation between 1961 and 1990, 5) share of workers in manufacture at t-10, 6) share workers in professional services at t-10 and, 7) share workers in trade at t-10.

<sup>20</sup> Lastly, (Glaeser and Saiz, 2003) define the following two regressions which are estimated through using OLS and fixed effects (year and region) to corroborate the reinvention hypothesis: 1) the dependent variable is the change logarithm of wage across 918 U.S. MSAs (metropolitan statistical area) and, 2) the dependent variable is



(Glaeser and Saiz, 2003:27-34) reach on as regards the first to the third sets of wage regression models are: a) there is a systemic positive relationship between initial human capital levels and later growth in family income at both the metropolitan area and city levels: “the baseline impact of having an extra 10 percent of an area’s adult population with college degrees is an increase in expected income growth of 2 percent”, b) the coefficient on schooling increased by 0,58 between 1970 and 1980, then by 0,21 between 1980 and 1990 and finally, an increment of 0,047 between 1990 and 2000, c) there is no regression where human capital is associated with declining real wages at the city level what leads to the conclusions that rising wages at the city level have everything to do with rising productivity and nothing to do with rising amenities, d) surprisingly, city size by means of initial conditions of population is negatively associated with real wages and finally, e) other factors such as average heating degree days, average annual precipitation show divergence effects: sometimes they are positively related to real wages, while others they exert a negative influence on wages; but in all case these effects are not statistically significant.

Next to these results, the main findings that (Glaeser and Saiz, 2003:40) obtain related to the reinvention hypothesis which is based on the idea that cities survive only by adapting their economies to new technologies –so it tells us that human capital predicts city growth (wage) because human capital enables people to adapt well to change-, are: a) there is a statistically significant negative interaction between warmth and initial skills on wage growth (with an elasticity value of -0,121), b) human capital matters much more in predicting wage growth in areas without immigrant (an elasticity value of 2,541) than in areas with immigrants (2,376) what imply that the reinvention hypothesis is correct, c) initial conditions of population as a proxy of city size, foster wage growth between the period 1990 and 2000 at metropolitan scale (MSA), d) natural amenities such as average heating degree days matters for wage growth, and it is negatively and statistically significant related to wage growth in this case and finally, e) immigrants (non-native workers) exert a negative and statistically significant effect on wage growth across 918 U.S. MSA between 1990 and 2000. Hence, the main contributions of the work carried out by (Glaeser and Saiz, 2003) are: 1) at the metropolitan level, the available evidence appears to show quite clearly that skills predict wages (productivity) growth and not an increase in amenity levels: the high skilled metropolitan areas are not seeing falling real wages; and consequently, 2) city growth can be increased with strategies that increase the level of local human capital: at the regional or metropolitan level, attracting high capital workers may require provision of basic services, amenities and quality public schools that will lure the most skilled.

To know more about the connection between wages and human capital, it is worth mentioning the research conducted by (Shapiro, 2005) in which presents a model of city growth<sup>21</sup> and

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the change logarithm of wage across 918 U.S. MSAs but in this case including two more independent variables. Thus, the determinants that (Glaeser and Saiz, 2003) define for the former model are: 1) share of bachelor’s (above 25 years) at t-10, 2) temperature\*share of bachelors at t-10, 3) logarithm of population at t-10, 4) logarithm of average heating degree days between 1961 and 1990, 5) logarithm of average annual precipitation between 1961 and 1990, 6) share of workers in manufacture at t-10, 7) share workers in professional services at t-10, 8) share workers in trade at t-10 and, 9) logarithm of average wage receipts per worker at t-10. Then, for the latter regression, (Glaeser and Saiz, 2003) use the nine previous mentioned determinants next to 10) share of immigrants at t-10\*share of bachelor’s at t-10 and, 11) share of immigrants at t-10.

<sup>21</sup> The empirical framework that Shapiro’s study defines is based on the following two equations: 1)  $k_L \Delta w_{i,t+1} + k_R \Delta p_{i,t+1} = H_{i,t} \beta^\alpha + X_{i,t} \gamma^\alpha + \epsilon_{i,t+1}^\alpha + k_L \mu_{i,t+1}^p + k_R \mu_{i,t+1}^w$  and, 2)  $s_R \Delta p_{i,t+1} - \Delta w_{i,t+1} = H_{i,t} \beta^q + X_{i,t} \gamma^q + \epsilon_{i,t+1}^q + s_R \mu_{i,t+1}^p - \mu_{i,t+1}^w$ , where  $(\beta^\alpha)$  and,  $(\beta^q)$  are the parameters relation human capital to growth in productivity and quality of life respectively;  $(\mu^p)$  and  $(\mu^w)$  are the measurement error in price and wage growth correspondingly;  $(H_{i,t})$  refers to human capital concentration;  $(X_{i,t})$  represents a vector of city characteristics and,

illustrates the explanations for the relationship between these two elements. In this sense, Shapiro's estimates two sets of regression models. The former, which constitutes the baseline results of its study, consists of regressing wage growth between 1940 and 1990 on determinants related to human capital and initial conditions<sup>22</sup> through using OLS (ordinary least squares) techniques. The latter is based on carrying out a robustness analysis considering the baseline wage regression model on the basis of 1) including weather controls, 2) lag growth controls, 3) using definitions of the spatial unit without changes over time and, 4) using instrument variable estimation<sup>23</sup>. The results that (Shapiro, 2005:16) reaches on as regards the baseline specification of its proposed wage growth regression model are: a) growth in wages tends to be higher in cities with greater concentrations of college-educated residents: "*a 10 percent increase in the share of college-educated residents corresponds to a 1,6 percent increase in wage growth*" and, b) higher initial conditions of wage in 1940 entails a lower level of wages in 1990 what may imply a process of convergence. Next to this, the findings that (Shapiro, 2005:19) points out related to examine the robustness of its baseline model are: a) the results by including weather controls is extremely closely with those in the baseline and the implied wage growth rises only slightly to 0,0163 (the baseline specification presents an elasticity of 0,0160), b) the inclusion of lagged employment growth rates increases somewhat the estimated effects of human capital on wage growth to 0,0329, c) by addressing the problem of changes in the composition of metropolitan areas over time, the estimated coefficient of human capital is also similar to the baseline specification (0,0260 versus 0,0160) and finally, d) the instruments variables results show larger growth effects of human capital: a 10 percent increase in the share of resident who are college-educated is now estimated to increase wage growth by about 2,4 percent, as against 1,6 percent in the baseline OLS specification. As a consequence, the main contribution of (Shapiro, 2005:24) is that there is a clear and a consistent casual effect between human capital and wage growth.

Another relevant work is research conducted by (Kim, 2006) in which by using firm-level data attempts to investigate a) the existence of urban agglomeration economies between the period 1850 and 1880 to estimate whether there were urban wage premium and, b) whether urban agglomeration economies has gained force over time in the explanation of urban wages. To test it empirically, as regards the former research question, Kim's study defines a

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finally, ( $\mathcal{E}^\alpha$ ) and, ( $\mathcal{E}^\eta$ ) are the shocks related to human capital to growth in productivity and quality of life correspondingly.

<sup>22</sup> The baseline specification that (Shapiro, 2005) proposes is based on: 1) the dependent variable is the wage growth between 1940 and 1990, in which wages are measured through, a) considering only prime-age males living across the 495 metropolitan areas under consideration, b) dividing total wage and salary income for each individual by total annual hours worked and finally, c) regressing the logarithm of the wage for each individual on dummies for each metropolitan area, age and its square, and dummies for veteran status, marital status, educational attainment, industry category and occupational category; 2) the determinants are 21) the logarithm of the population share with college education, which is measured as the share of prime-age white males who have a high school degree only, some college, and a college degree or higher and, 22) the initial conditions of wage measured as 1); and finally, 3) including in the regression model time period dummies.

<sup>23</sup> The second set of regression models proposed by (Shapiro, 2005) starts from the same baseline wage regression model mentioned in the previous cite 22, but including the following changes to check the robustness in the baseline specification: 1) controlling for weather on the basis of including 11) mean January temperature, 12) mean July temperature and, 13) average annual inches of precipitation through using data provided by the County and City Data Book in 1994, 2) controlling for lag growth on the basis of including lagged employment growth between the period of 1970 and 1990, 3) controlling for the changes in the composition of metropolitan areas over time through considering a sub-sample of metropolitan area-year pairs in which the definition of the metropolitan area does not change during the time period and finally, 4) estimating the baseline specification through using instrument variables on the basis of defining as instruments, 41) the presence of land-grant college and universities in 1862 and, 42) compulsory schooling laws between 1914 and 1965 based on the minimum years of schooling required before leaving school and, the minimum years in school required before working.

regression model<sup>24</sup>, which is estimated through OLS (ordinary least squares) techniques and instrument variables<sup>25</sup>, by considering 5 different model specifications (one for each decade considered between the period 1850 and 1880) and, in which the dependent variable is the logarithm of the average annual wage of a given establishment or firm in 1850, 1860, 1870, 1880 and, the explanatory determinants are related to a) the localization of the firm (in urban location or not), b) firm-level characteristics and, c) a set of fixed effects (county or state, and industry fixed effects). Next to this, (Kim, 2006) to explore the robustness of its former analysis, estimates through using instrument variables the same set of regression models with considering another measures of urban agglomeration: 1) the share of population in cities with population of 2500 or more, 2) the share of population in cities with population of 25000 or more, 3) the total county population and, 4) the county population density. Then, in accordance with the latter research question, Kim's work estimate a pooled difference-in-difference wage regression model<sup>26</sup> between 1860 and 1880 through using OLS techniques.

Consequently, the results that (Kim, 2006:9-14) reaches on, as regards the former analysis, are: a) the OLS regression estimates indicate that workers in urban firms consistently earn higher wages on average than those of rural firms: *"in 1850 and 1860, urban wages were 10,5 and 7,3% higher than rural wages, in 1870 and 1880, they were 22,1 and 46,2% higher"*, b) the IV regression estimates considerably higher elasticities of urban location to wages compared to the elasticities estimated by using OLS techniques: workers of urban firms earned 47%, 22%, 83% and 78% higher wages than those of rural firms for 1850, 1860, 1870 and 1880 respectively, c) for the capital intensity variable which is positively and statistically significant associated with wages, the OLS and IV regression estimates a very similar coefficient: *"in 1850 and 1860, a percentage increase in capital intensity increased wages by 6%, but the figures rose to 18 and 19% in 1870 and 1880, respectively"*, d) firms with a higher share of male workers paid higher average wages, e) others variables such as workers in water-powered factory or steam-powered factors do not have a conclusive effect on wages: their effects are significant or not statistically significant depending on the year under consideration (1850, 1860, 1870 and, 1880) and finally, when are considered other indicators for measuring agglomeration economies, the results show that, d) all of them are positively and statistically significant related to wages at the time that their estimated coefficient have

<sup>24</sup> The regression model that (Kim, 2006:5) estimates is:  $\ln(W_{ic}) = \alpha_0 + \alpha_1 Urban_{ic} + \alpha_2 F_{ic} + d_l + d_j + u_{ic}$ , where ( $w_{ic}$ ) is the average annual wage of firm (i) in county (c); ( $Urban_{ic}$ ) is a dummy variable for whether firm (i) is located in an urban location or in an rural location which is defined as urban location if a county contains a population of at least 2500 inhabitants; ( $F_{ic}$ ) is firm-level characteristics; ( $d_l$ ) is location (county or state) fixed effect and finally; ( $d_j$ ) is industry fixed effect at 3-digit industry level. Next to this the independent variables that (Kim, 2006) defines are: 1) urban, 2) logarithm of the capital-labor ratio as proxy for capital intensity, 3) men labor ratio as a proxy of sex composition of workers, 4) factory, 5) steam, 6) water, 7) the interaction between steam and factor and finally 8) the interaction between water and factory. Finally, in the case of the regression models estimated through OLS techniques, Kim's study includes county and 3-digit industry fixed effects; while in the case of using instrument variables, the fixed effects included are state and 3-digit industry fixed effects.

<sup>25</sup> The instrument variables that (Kim, 2006:5) defines are: 1) a lagged urban variable which, 11) for the 1850 regression, the lagged urban variable is the share of the county population that was urban in 1840 and, 12) for the 1860-1880 regressions, the lagged urban variable is the share of the county population that was urban in 1850; by considering in both cases that the urban threshold is that population exceeds 2500 inhabitants; 2) access to water transportation, 3) distance to the eastern seaboard and, 4) county date of incorporation.

<sup>26</sup> The pooled regression that (Kim, 2006) estimates takes the following form:  $\ln(w_{ict}) = \alpha_0 + \alpha_1 Urban_{ict} + \alpha_2 F_{ict} + \alpha_3 d_t Urban_{ct} + d_t + d_l + d_j + u_{ict}$ , where ( $\alpha_3$ ) is the parameter that indicates whether agglomeration economies have gained force over time or not: if ( $\alpha_3$ ) is positive, then agglomeration economies are likely to have increased over time. The explanatory variables that (Kim, 2006) defines in this case, apart from including state and year fixed effects, are: 1) urban, 2) year dummy for 1860, 3) year dummy for 1870, 4) year dummy for 1880, 5) year dummy for 1860\*urban, 6) year dummy for 1870\*urban, 7) year dummy for 1880\*urban, 8) logarithm of the capital-labor ratio, 9) men-labor ratio, 10) factory and finally, 11) steam.

increased over time (between 1850 and 1880) with a remarkable emphasis of the agglomeration indication based on share of population in cities with population of 25000 or more which holds the highest estimated positive coefficient which ranges from 0,23 in 1850 to 0,37 in 1880 respectively.

Then, the results that (Kim, 2006:14-15) reaches on, as regards the latter analysis, indicate that: a) urban wage increased significantly between the period 1850 and 1880: the estimated coefficient of the dummy variable for 1860 is 0,10; while for 1880 the estimated coefficient is 0,30, b) workers in urban firms earn 11% more than workers in rural firms, c) the interaction between dummy variable and urban location present that the greater this interaction the higher the wages: the estimated coefficient of dummy variable in 1880 and urban location is 0,30 and finally, d) capital and male intensity, steam and water-powered factory variable are positively correlated with wages, indicating an elasticities values of 0,15; 0,94; 0,11 and, 0,09 correspondingly. Hence, the main conclusion that (Kim, 2006:21) points out are: workers in urban firms are paid significantly higher wages relative those in rural firms in every decade during the period of 1850 and 1880 at the time that urban wage-premium rose over time as well as the influence of agglomeration economies on wages: *“The data show that urban firms paid higher wages to their workers and that urban premiums in wages increased over time. The urban wage-premium accrued to both skilled (male) and unskilled (female) workers throughout the entire period. The urban skilled-unskilled wage gap seems to have narrowed in 1850 and 1860, but may have widened in 1880. As expected, other firm-level characteristics such as capital intensity and skill intensity (male labor intensity) were also associated with higher wages. When the data were pooled over the entire period, those workers who worked in water and steam-powered factories also tended to earn higher wages when controlling for all other factors”*

Next to Kim’s work, in a different vein, but also by taking into account the spatial effects of urban agglomeration economies on wages, the study carried out by (Rice et al., 2006) through using NUTS-3 sub-regional data for Great Britain aim to analyze the determinants of spatial in earnings across 119 sub-regional units between the period of 1998 and 2001. To do so, Rice’s study formulates the following research questions: a) the determinants of performance across areas: are differences in performance related to proximity (time) to centres of activity, as hypothesized by many theories of location and spatial clustering? and, b) what is the spatial scale of these effects? and, how large are them?. In this sense, to address econometrically, the former question, Rice’s study defines a set of regression models<sup>27</sup> which are estimated through using a) OLS (ordinary least squares) techniques with and without regional dummies), b) spatial lag model with regional dummies and, c) instrument variables<sup>28</sup> with regional dummies, in which the dependent variables are based on the four different definitions

<sup>27</sup> The estimated equation that (Rice et al., 2006) define is:  $\ln y_i = \beta_0 + \sum_b \alpha_b p_{bi} + \sum_j \beta_j x_{ji} + \varepsilon_i$ , where ( $y_i$ ) are the dependent variables that the study carried out by (Rice et al., 2006): 1) GVA per (employee) hour worked, 2) average hourly earnings, 3) occupational composition index and, 4) productivity index; ( $p_{bi}$ ) denotes the population of working age within the proximity band ( $b$ ) of area ( $i$ ) and; ( $x_{ji}$ ) is the value of the ( $j$ )th control variable in area ( $i$ ). Therefore, the independent variables that Rice’s study defines are: 1) Population of working age within 40 minutes travel time, 2) Population of working age within 40 and 80 minutes travel time, 3) Population of working age within 80 and 120 minutes travel time, 4) logarithm of percentage of economically active population with a degree level qualifications and finally 5) logarithm of percentage of economically active population with no formal educational qualifications.

<sup>28</sup> The instruments variables that (Rice et al., 2006:741) define are: 1) population in the area within 10 miles in 1851, 2) within 20 miles, 3) within 40 miles, 4) within 50 miles, 5) within 80 miles, 6) logarithm of percentage of economically active population with degree of level qualifications and finally, 7) logarithm of percentage of economically active population with no formal educational qualifications.

of spatial earnings variations<sup>29</sup> that its study proposes and, the explanatory determinants are related to 1) a measure of economic mass (population of working age) and, 2) a set of additional controls for considering other area specific characteristics that may affect spatial earnings variations. Next to this, to test empirically the latter question (Rice et al., 2006) proposes to estimate a set of spatial decay models<sup>30</sup> which are estimated through using a) NLSS (non-linear least squares) techniques with and without regional dummies and, b) instrument variables<sup>31</sup> with regional dummies, in which also the dependent variables are based on the four aforementioned measures of spatial income variations and, the independent variables are related to 1) a measure of economic mass (population of working age within travel time band), 2) the decay rate based on the relative weight attached to successive economic mass (population bands) and finally, 3) additional variables to control for other area specific characteristics.

Hence, the results that (Rice et al., 2006:737-742) point out, as regards the former question, are: a) earnings increase with the population of working age up to a distance of some 80 minutes travel time from the center of the sub-region; the quantitative impact of population declines with distance with the coefficients on the 40 to 80 minutes band significantly smaller than that for the 0 to 40 min, by then beyond 80 minutes the population effects are statistically insignificant: the OLS and spatial lag estimated coefficients are 0,0512 and 0,0539 for the first band distance respectively, next to 0,0149 and 0,0161 for the distance band between 40 and 80 min correspondingly and lastly, 0,0037 and 0,039 for the distance band within 80 and 120 minutes, b) the same observation as regards the connection between earnings and population is occurring related to the instrument variable estimation, although in this case the elasticities are quite higher: the estimated coefficient is 0,0584 for the distance band within 40 minutes travel, by then decreases to 0,0133 within 40 and 80 minutes travel and, lastly it becomes statistically insignificant with an elasticity value of 0,007 within 80 and 120 minutes travel time, and finally, c) the others controls are significant in all cases (OLS, spatial model

<sup>29</sup> The four different measures that (Rice et al., 2006) define as regards spatial earnings variation, which each one will be used as dependent variables, are: 1) GVA per (employee) hour worked ( $g_i$ ) which is estimated through using workplace-based gross value added at basic prices, 2) Average hourly earnings ( $e_i$ ) which is estimated by using the average hourly earnings of all full-time employees, 3) Productivity index which is the weighted sum of the average earnings of each occupational group in area (i), with weights equal to the share of the occupational group in total Great Britain employment ( $q_i = \sum_k w_i^k \bar{\lambda}^k$ ) and finally, 4) Composition index which is measured as the weighted sum of the shares of each occupational major group in employment in area (i), with weights equal to the Great Britain average earnings of the occupational major group ( $c_i = \sum_k w_i^k \bar{\lambda}^k$ ). Because of in this paper, we are trying to analyze the impact of agglomeration economies and other variables on wages, we decide to report here, only the results that (Rice et al., 2006) have reaches on average hourly earnings per employee between 1998 and 2001.

<sup>30</sup> The spatial decay function that Rice's work determines takes the following functional form:  $\ln y_i = \beta_0 + \alpha \ln[\sum_b p_{bi} \exp(-\theta(t_b - 30)/30)] + \sum_j \beta_j x_{ji} + \varepsilon_i$ , where as previously, ( $y_i$ ) are the dependent variables proposed by Rice's study (see, the previous cite 29); ( $p_{bi}$ ) is the population of working age within travel time band with outer edge ( $t_b$ ) minutes from area (i) and;  $\exp(-\theta(t_b - 30)/30)$  is the weight attracted to this population band. Next to this, according (Rice et al., 2006:739) travel time bands are computed for population within 30 min and then at 10 min intervals, so ( $t_b$ )=[30,40,50,...120]; the functional form assumes that weights decline exponentially with decay rate ( $\theta$ ) measuring the relative weight attached to successive population bands in the mass index; the parameter ( $\alpha$ ) measures the elasticity with respect to the mass index as a whole and finally, the parameters ( $\beta_j$ ) represents the additional controls which are: 1) logarithm of percentage of economically active population with degree of level qualifications and, 2) logarithm of percentage of economically active population with no formal educational qualifications.

<sup>31</sup> The instrument variables that (Rice et al., 2006) define for the spatial decay model are: 1) population in the area within each 10-mile distance band between 10 and 80 miles in 1851, 2) logarithm of percentage of economically active population with degree of level qualifications and finally, 3) logarithm of percentage of economically active population with no formal educational qualifications.

and instrument estimations) and they present the expected sign: a higher proportion of the population qualified to first degree or higher is associated with a higher level of income in this area, while the reverse is true for the proportion of unqualified workers.

Then, the results that (Rice et al., 2006:740-745) point out, as regards the latter question on the basis of 1) what is the spatial scale of the agglomeration effects on wages and, 2) how large are them, are: a) the estimated coefficient of the earnings with respect to economic mass is 0,0482 (and it is statistically significant) when is used NLS (non-linear least squares) techniques, while when is used instrument variables estimation, the estimated elasticity of the average hourly earnings with respect to the mass index as a whole is 0,0698, b) similarly, the estimate of the relative weight attached to successive population bands in the mass index which is 1,4110 and 1,2045 for NLS and IV estimations respectively, indicates that effects decline with distance and, c) as previously, the other skills control variables exert an statistically significant effect (with the expected sign) on earnings; then, next to this, as regards the quantification of agglomeration effects on earnings, d) moving a mass of population 30 min further away reduces its impact on wages by three-quarters: “a person of working age between 60-70 min away has just 25% of the impact on productivity compared to an individual 30-40 min away”, e) the elasticity of earning with respect to distance-weighted spatial mass and its estimated is 0,06898 what it implies that an elasticity of 0,06898 means that doubling the spatial mass that an area increases its earnings by 4,89% ( $2^{0,06898}-1$ ). Consequently, the main findings that Rice’s study reaches on are: a) a robust and quantitatively important determinant of variation in earnings between 119 NUTS2 regions of Great Britain is the proximity of each area to economic mass, although this effect is decreasing with distance to the point that far away of 80 minutes travel is not statistically significant, b) the magnitude of the economic mass effects on earnings is 4,89% and finally, c) human capital is also a robust determinant of average hourly earnings.

In a similar vein, but by considering wage growth, it is important to mention the study of (Wheeler, 2006). Its study, through using data of a sample which includes 1258 male workers who held a total of 5150 jobs between 1978-1994 across 385 U.S. local markets (204 of them are metropolitan areas and 181 of them are non-metropolitan counties) and provided by National Longitudinal Survey of Youth 1979 Cohort (NSLY79), attempts to examine the relationship between overall wage growth and the scale of worker’s local market. To test it empirically, Wheeler’s study estimate a wage equation<sup>32</sup> through using OLS (ordinary least squares), in which the dependent variable is the total wage growth (in annual rates), and the explanatory variables are related to a) a vector of characteristics for worker including: educational indicators, race, marital status, experience etc..., and, b) a set of measures of worker’s local market size which defines the different 6 model specifications<sup>33</sup> proposed by

<sup>32</sup> To investigate whether overall wage growth is faster in larger markets, (Wheeler, 2006) defines the following wage growth equation:  $G^i = \alpha + \beta'X^i + \gamma z^i + \varepsilon^i$ , where ( $G^i$ ) is the dependent variable calculated as follows,  $G^i = \frac{1}{t_{j_i,end}^i - t_{i,start}^i} (w_{j_i,end}^i - w_{i,start}^i)$ , so overall (average) wage growth is the difference between the worker’s first and last observed logarithm wages, normalized by the total number of weeks that have transpired between the date on which these wages are observed; ( $\alpha$ ) is a constant; ( $X^i$ ) is a vector of characteristics for worker (i), including three educational attainment indicators (bachelor’s degree or higher, some college or an associate’s degree, high school diploma only), race, marital status, and a quadratic in cumulative weeks of work experience; ( $z^i$ ) is a measure of worker i’s local market size; and finally ( $\varepsilon^i$ ) is a stochastic terms assumed to be uncorrelated across individuals (i).

<sup>33</sup> The independent variables that Wheeler’s work determines as regards the vector of characteristics for worker are: 1) college, 2) some college, 3) high school, 4) experience, 5) experience squared, 6) married and, 7) non-white workers. These variables constitute the basic model specification in which by including the determinant 8) AFQT (Armed forces qualifications test) score, (Wheeler, 2006) defines two clear model specifications: with and

(Wheeler, 2006). Hence, the results that (Wheeler, 2006:168-170) reaches on are: a) workers with higher levels of education imply a higher increment of average rate of overall wage growth than workers with lower levels of education: the estimated coefficient of college is 0,028, while for some college and high school are 0,024 and 0,012 respectively, b) wage growth tend to be faster among white and those are married: the elasticity of non-white workers is -0,017, while for married workers is 0,014, c) experience and its square do not produce significant coefficients, although these variables holds the expected sign, which is consistent with a standard hump-shaped age-earnings profile, d) there is a positive association between overall average wage growth and each of the indicators of local market scale entailing that d1) a 1 standard deviation increase in a local labor market's population tends to be accompanied by a 0,23 percentage point rise in a worker's average hourly earnings growth (at an annual rate), d2) 0,27 percentage point rise on overall wage growth because of increasing 1 standard deviation in population density and finally, d3) 0,43 point rise in wage growth whether local labor market's diversity increases in 1 standard deviation. Consequently, the main contribution to the literature of the study carried out by (Wheeler, 2006) is that overall earnings growth does tend to be faster in large, economically diverse local labor markets –defined as counties and metropolitan areas- than in smaller, more specialized markets at the time that human capital (skilled workers) are also playing an important role to foster higher wage growth in these local labor markets.

Taking the same source of data and following the work of (Glaeser and Maré, 2001) as a point of departure, the research conducted by (Yankow, 2006) extends their analysis by providing new evidence on the sources of the urban wage premium through using an extensive panel of data drawn from the National Longitudinal Survey of Youth 1979 (NLSY79) which is based on a sample of 3490 young men contribution 23956 observations over the years 1979-1994 across cities and non-urban cities<sup>34</sup> and, by examining the wages of urban and non-urban workers across 2 distinct modes<sup>35</sup>: a) wage levels and, b) year-to-year wage growth by considering the following well-known hypothesis studied in-depth in the literature: 1) cost of living differences, 2) ability-sorting hypothesis, 3) firm-level productivity hypothesis, 4) learning hypothesis and, 5) coordination hypothesis<sup>36</sup>.

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without considering this last determinant. Next to this, Wheeler's study define the following three explanatory variables as regards local market size which conjointly with the two previous specifications form the final six different model samples: 9) the logarithm of total resident population, 10) the logarithm of population density and, 11) an index of industrial diversity (Dixit-Stiglitz's index) which is calculated as follows:  $Diversity = (\sum_k (\frac{Emp_k}{Emp})^{1/2})^2$ , where  $(Emp_k)$  is the total employment in 4-digit SIC industry (k) in the local market,  $(Emp)$  represents total employment and, by construction, larger values of the index represent greater diversity.

<sup>34</sup> Yankow's study define a city as a metropolitan statistical area (MSA) which holds more than 250000 inhabitants next to non-urban city as all metropolitan and rural areas with population less than 250000 inhabitants. In addition, within cities (above 250000 inhabitants), Yankow's work distinguishes those have more than 1 million people which are classified as big cities and, those have between 250000 and 1000000 inhabitants which are defined as small cities.

<sup>35</sup> Apart from these two modes, (Yankow, 2006) also considers the effects of urban and non-urban workers on between-job wage growth. However, we do not consider this mode in this work because it is not specifically useful for the empirical framework that we attempt to develop in the following Section 4. The main reason as regards between-job wage growth is not considered in the following Section 4 of this paper is because this data is not available for the Barcelona Metropolitan Region, our study case.

<sup>36</sup> According to (Yankow, 2006:141-143) the competing hypotheses are: 1) cost of living differences on the basis of if a high cost of living in cities could explain wage difference between urban and non-urban workers, 2) ability-sorting hypothesis which is related to the fact that a plausible explanation for the urban wage premium is that cities demand, attract, and retain higher-quality workers than do employers in non-urban areas, 3) firm-level productivity hypothesis which asserts that workers are more productive in firms located within cities due the economies of agglomeration, 4) learning hypothesis which postulates that cities speed the rate of human capital accumulation and consequently that urban density accelerates the rate of interaction between people and that

To test empirically the influence of wages of urban and non-urban workers by considering wage levels between 1979 and 1994, (Yankow, 2006:145) estimates three wage regression models, one for each considered estimation method: 1) OLS (ordinary least squares), 2) fixed-effects models and, 3) experience effects<sup>37</sup>; which imply a total set of ten different model specifications (without taking into account the cost of living) or a set of 9 different model specifications (by considering the effects of the cost of living on wage levels) and; in which the dependent variable is the logarithm of the regional CPI-deflated (consumer price index) hourly wage for worker or the logarithm of the regional hourly wage for worker (with unadjusted, full adjusted or partial adjusted consumer price index when cost-of-living is considered) and, the determinants are related to a) a vector of personal, job and labor market characteristics, b) the location of workers' residence (city or not and big or small city) and, c) a set of year dummy variable for the years between 1979 and 1993<sup>38</sup>. Next to this, as regards the latter analysis, (Yankow, 2006:152) defines a set of wage growth models<sup>39</sup> in which the dependent variables are based on: 1) annual change in logarithm wages, 2) four year change in wages, 3) wage level in the year prior to move, 4) relative wage level in the following year to move and, 5) wage earned four years after a move and, the explanatory variables are related to a) a vector of personal, job and labor market characteristics, b) dummy variables designating various types of residential movement (workers moving into and out of cities, migration into an urban area, migration out of an urban area and, urban residence in the first year) and, c) a set of year dummies.

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when people learn through interactions, human capital accumulation is accelerated and finally, 5) coordination hypothesis which holds that urban density facilitates the matching of workers and firms.

<sup>37</sup> The three baseline wage equations that (Yankow, 2006) estimates are the following ones. In the first time, the OLS' models takes the following form:  $\ln W_{it} = \sum_{h=1}^H \beta_h \Delta X_{iht} + \sum_{k=1}^2 \gamma_k CITY_{ikt} + \sum_{m=1}^{M-1} \tau_m YEAR_{imt} + \varepsilon_{it}$ , where ( $W_{it}$ ) is the logarithm of the regional CPI-deflated hourly wage for worker ( $i$ ) at time ( $t$ ); the vector ( $X$ ) contains ( $H-1$ ) personal, job, and labor market characteristics; ( $\beta$ ) contains the corresponding coefficients ( $X_i=1$  and  $\beta_1$  is the intercept); ( $CITY$ ) contains two dummy variables designating residence in urban areas of different population size: residence in an urban area with population greater than one million (Big city) and residence in an urban area with population between 250000 and one million (Small city); ( $\gamma$ ) are the adjusted earnings difference by urban residence status relative to non-urban residents, ( $YEAR$ ) includes dummy variable for the years 1979 to 1993 and finally; ( $\varepsilon_{it}$ ) is assumed to be a well-behaved error term. Next to OLS' model, the fixed effects model proposed by (Yankow, 2006) is expressed as follows:  $\ln W_{it} = \sum_{h=1}^H \beta_h \Delta X_{iht} + \sum_{k=1}^2 \gamma_k CITY_{ikt} + \sum_{m=1}^{M-1} \tau_m YEAR_{imt} + \alpha_i + \varepsilon_{it}$ , where ( $\alpha_i$ ) account for unobserved personal differences fixed over time. Then, the experience effects' model according to (Yankow, 2006:149) is based on 1) estimating as a first stage,  $z_{it} = \phi_1^z + \phi_2^z e_{it} + \phi_3^z e_{it}^2 + v_{it}^z$ , where ( $z_{it}$ ) denote an arbitrary variable used in the analysis and ( $e_{it}$ ) denote years of potential experience and, 2) using as a second stage the residuals of the previous dependent variable and regressing them on the residuals of the independent variables using a fixed-effect estimator. Finally, in each of these mentioned wage regression models, (Yankow, 2006) also controls for the cost and living (is expected that large cities pay workers a wage premium. However, large urban areas, have a higher cost of living than less densely population areas) and consequently, each of them are reformulated through using: 1) the logarithm of unadjusted CPI-deflated hourly wage, 2) the logarithm of full cost-of-living-adjusted CPI-deflated hourly wage and finally, 3) the logarithm of partial cost-of-living-adjusted CPI-deflated hourly wage as dependent variables.

<sup>38</sup> The independent variables that Yankow's work define are: 1) Big city, 2) Small city, 3) Black workers, 4) Hispanic workers, 5) HGA which is the urban residents with highest grade attended, 6) Experience, 7) Experience (square and divided by 10), 8) AFQT (armed forced qualifications test), 9) AFQT miss, 10) Married workers, 11) Tenure, 12) Tenure (square and divided by 10), 13) Government and finally, 14) Workers belonging to a union.

<sup>39</sup> The baseline annual wage growth regression model that (Yankow, 2006) define is:  $\Delta \ln W_d = \sum_{h=1}^H \beta_h \Delta X_{hd} + \sum_{k=2}^K \gamma_k \Delta CITY_{kd} + \sum_{d=2}^D \phi_d PERIOD_d + \varepsilon_d$ , where ( $d$ ) indexes the time periods over which values are differenced and ( $PERIOD_d$ ) are dummies for the periods 1980-1981 through 1993-1994; the vector ( $\Delta CITY_{kd}$ ) contains ( $K$ ) dummy variables designating various types of residential movement into (or out of) urban areas, with the coefficients in ( $\gamma$ ) meant to capture the return to urban migration and residency, ( $X$ ) capture all the independent variables explained conjointly in the previous cites 37-38 and finally, ( $W_d$ ) is the difference in logarithm wages on the basis of the five different differences that Yankow's study defines.



The results that (Yankow, 2006:145-149) reaches on as regards the former analyses are: firstly related to the fact that cost of living is not controlled, a) the best estimation of the coefficient as regards big cities is 0,220 suggesting that workers in large cities receive almost a 25 percent wage premium over workers residing outside of urban areas, although this coefficient decreases to 0,190 when is controlled for racial composition and education, to 0,175 when is controlled for personal workers characteristics (e.g. married, belonging to a union etc...) and to 0,054 and 0,052 when is used fixed-effects and experience effects models respectively, b) an estimated coefficient of small city measured at 0,095 suggesting a 10 percent wage premium for small city resident relative to non-urban workers, although the estimated elasticity for small cities decreases to 0,069 when black, hispanic and skilled workers are controlled, to 0,076 when are included all determinants and to 0,038 and 0,032 when is used fixed-effects and experience effects models correspondingly; secondly when the regression models consider cost of living effects, c) the estimated coefficient of big cities is 0,044 and the coefficient estimated for small cities is 0,051 when is applied the full COL-adjusted what indicates that workers in small cities receive a 5,1 percent wage premium over workers residing outside of urban areas and a 0,7 percent more than workers residing in big cities, d) when is applied a partial COL-adjusted, big cities present a higher elasticity compared to small cities measured at 0,121 compared to 0,042 respectively, e) as previously, fixed effects and experience effects models decreases the estimated coefficients of big and small cities at the level of 0,052 and 0,047 for big cities respectively and of 0,028 and 0,019 for small cities correspondingly, and finally, f) across the different estimation techniques and with and without considering cost of living, it is worth mentioning that black and hispanic workers as well as workers with a greater experience (experience square) are negatively and statistically associated with urban wage premium, while educated and experience workers as well as married and tenure workers are positively and statistically significant related to wages.

Then, as regards the latter empirical analysis (Yankow, 2006:153-156) points out the following findings: a) the estimated coefficient related to workers moving into and out of cities is 0,059 and is significant at 5 percent level what implies that working moving into cities from non-urban areas experience 6 percent (5,9%) higher wage growth during the year of the move, when compared to workers either living in a city for both years or living outside of an urban area for both years, b) the coefficient estimate for workers which its urban residence in the first year is a city, is 0,013 and consequently, that working living in a city in both periods experience slightly faster wage growth than workers residing outside of urban areas, c) the coefficient of the variable which measures the change in wages of non-urban-to-urban migrants relative to workers remaining in non-urban areas is 0,061 what means an increment of 6 percent in wage for city migrants, d) the estimated coefficient for out-city which captures the wage change of a worker who moves from a city to a non-urban area is -0,069 entail that working moving out of cities experience about a 7 percent wage reduction relative to city stayers and a 6 percent (-0,069+0,013) compared to of non-urban workers, e) there is a similar wage growth rate between city natives (those workers to reside in city in years t and t+1: first and second dependent variable) and the non-urban control group, f) the positive and significant estimate for migrants to city (in-city) indicates that workers who moved into cities between years (t) and (t+1) experience a post-migration growth rate in wages that is greater than either native city workers or non-urban workers, g) the insignificant coefficient estimate of 0,009 for out-migrants (out-city) shows that the wage of urban-to-non-urban migrants also grew at the same rate as the control group, h) workers living in cities earned wages that are nearly 20 percent larger than workers living in non-urban areas in period (t), i) the estimate coefficient of 0,039 for in-migrants to cities reveals that workers residing in a non-urban area in the first years, but who subsequently move to a city in the next

year, earned wages roughly equivalent to other workers living in non-urban areas (who subsequently do not move into cities) and, as a result: “*this it works against the ability-sorting hypothesis, which predicts these movers would have earned superior wages in their location of origin*”, j) the estimate coefficient for in-city (considering the fourth dependent variable) is 0,088 and statistically significant, indicating that workers who moved from non-urban areas into cities in this case receive wage more than 9 percent higher than non-urban workers, although the wages of these city migrants are still nearly 10 percent lower than city natives (which are 19,1 percent), and finally; as regards the last dependent variable (four years after move, t+4), k) workers living in cities collect wages that are 20 percent higher than non-urban workers, l) the coefficient estimated for in-migrants is 0,170 and highly significant what indicates that it is closing the gap between native workers and in-migrants workers to cities and, m) the estimated coefficient for out-migrants (out-city) is -0,122 indicating that workers that move to urban-to-non-urban areas have decrease its wage to 12,2 percent in four years.

Consequently, the main conclusions that (Yankow, 2006:160) presents are that: a) urban areas are positively and statistically related to higher wages: “*OLS regressions reveal a 19 percent wage difference between workers in large urban areas and non-urban residents and, fixed-effects panel estimates indicate that about two-thirds of this wage premium can be explained by cities attracting workers of higher unmeasured skills and ability*” that. at the time that, b) wage growth analysis revealed a distinct symmetry in the wage changes between in-city and out-city migrants what is highly consistent with the productivity hypothesis: “*recent migrants to cities do not receive the bulk of the urban wage premium upon arrival but only after time spent in the city*” what is related to the learning and coordination hypotheses.

In the same line of research and extending the study of (Rice et al., 2006), the work carried out by (Di Addario and Patacchini, 2008) attempt to analyze empirically the impact of urban agglomeration on Italian wages focusing on a) urban wage premium and its spatial decay and, b) the urbanization effects on earnings determinants through using micro-data from the years 1995, 1998, 2000 and 2002 on more than 22000 employees distributed in 242 local labour markets (LLM). The former analysis is carried out by Di Addario and Patacchini’s study through defining a wage regression model<sup>40</sup> which is estimated by OLS (ordinary least squares) and instrument variables<sup>41</sup> techniques and, in which the dependent variable is the logarithm of employee’s hourly wage rates and the independent variables are related to a) years of schooling, b) quadratic form of experience, c) urban effect and, d) other individual characteristics<sup>42</sup> what imply testing seven different model specifications. Next to this, agglomeration effect on wage premium is established; Di Addario and Patacchini’s work estimates the rate at which the wage-urbanization relationship attenuates with distance by

<sup>40</sup> The wage regression model that Di Addario and Patacchini’s study proposes is:  $\log w_i = \alpha_0 + \alpha_1 EDU_i + \alpha_2 EXP_i + \alpha_3 EXP_i^2 + \alpha_4 TEN_i + \alpha_5 TEN_i^2 + \alpha_6 URBAN_i + Z_i\beta + u_i$ , where the ( $w_i$ ) is the dependent variable which is calculated as the logarithm of employees’ hourly wage rates from primary activities, deflated with the consumer price index for blue-collar worker and employee households; ( $EXP$ ,  $EXP^2$ ,  $TEN$  and,  $TEN^2$ ) represent experience, experience (square), tenure and tenure (squares) which are the standard Mincerian variables; ( $Z_i$ ) is a vector of individual characteristics which includes: ability, family background, job qualification, firm size, industry dummies, type of contract, the unemployment rate, region-specific effects and year dummies; ( $URBAN$ ) is the local labour market population mass which captures the urban effect and finally, ( $u$ ) is the error terms of the regression model.

<sup>41</sup> In this sense, (Di Addario and Patacchini, 2008) decide that local labour market population is instrumented with soil type characteristics: local labor market covered by water, marsh or agriculture.

<sup>42</sup> Consequently, in accordance with Di Addario and Patacchini’s work, the independent variables included are: 1) local labour market population, 2) basic controls, 3) sector and size of firm, 4) type of work-contract, 5) occupation, 6) non-linear education, 7) region-specific fixed effects, 8) family background and finally, 9) ability.

defining a wage regression model<sup>43</sup> in which the dependent variable and the determinants are the same as the previously with the difference that the urban effect variable included now in the model is able to assess the spatial scale of the population mass effects by comparing estimates across rings<sup>44</sup>. Then, related to the latter empirical analysis based on examining whether urbanization effects on the structure of wages, (Di Addario and Patacchini, 2008) uses its aforementioned proposed baseline wage regression model but now including the interactions between all the regressors and the population size's effect<sup>45</sup>.

The results as regards the connection of urban wage premium and agglomeration that (Di Addario and Patacchini, 2008:1049-1053) reach on are: a) the OLS estimated coefficient of local labor market population which ranges from 0,0071 to 0,0142 is always positively and statistically significant what imply that there is an evidence of the existence of an average urban wage premium because of every additional inhabitants in the local labour market provides workers with 0,1 percent higher wages, b) the instrument variable estimated coefficient of local labor market population is 0,0132 which is higher compared to the population coefficient estimated through OLS, c) education and experience and their squares forms are highly significant in all the specification and they follow a concave function (square of education and firm tenure are negatively associated with urban wage premium, while education and firm tenure are positively related to it) indicating that c1) a marginal increase in firm-specific human capital raises wages by about 5 percent and, c2) an extra year of education increases wages by 2 percent, and finally, as a result, d) this confirms the existence of an urban wage premium and the presence of productivity-enhancing agglomeration economies more than offset any labour-market congestion effect due for example to workers' preferences for large-city amenities.

Next to this, the results as regards the spatial decay model (if the wage-urbanization relationship attenuates with distance) that (Di Addario and Patacchini, 2008:1054-1055) point out are: a) a 100000 inhabitant increase within 4 kilometers raises wages by an interval (depending on the considered model specification) from 0,098 to 0,215 percent, b) a 100000 inhabitant increase within 4 and 8 kilometers raises wages from 0,041 to 0,11 percent, c) a 100000 inhabitant increase within 8 and 12 kilometers raises wages from 0,016 to 0,085 percent, d) the effect of population mass within 12 and 16 kilometers is not statistically significant, although it is positive and consequently, e) is confirmed that the effect of agglomeration economies on wage is attenuated with distance.

<sup>43</sup> The wage equation that (Di Addario and Patacchini, 2008) defines in this case is the following form:  $\log w_i = \alpha_0 + \sum_k \alpha_k (\delta_{r,k} Pop_{i,r}) + MV_i \beta + Z_i \gamma + u_i$ , where  $(\delta_{r,k})$  is the share of the ( $r^{\text{th}}$ ) LLM (local labour market) population ( $Pop_{i,r}$ ) afferent to the ( $k^{\text{th}}$ ) band (with  $k=1, \dots, 4$ ); and finally  $(MV_i)$  and,  $(Z_i)$  are respectively the standard variables and the vector of individuals characteristics presented in the model proposed by Di Addario and Patacchini previously (see, cite 40).

<sup>44</sup> In this sense, the independent variables that (Di Addario and Patacchini, 2008) defines are: 1) population mass within 0 and 4 kilometers, 2) population mass within 4 and 8 kilometers, 3) population mass within 8 and 12 kilometers, 4) population mass within 12 and 16 kilometers, 5) basic controls, 6) sector and size of firm, 7) type of work-contract, 8) occupation, 9) non-linear education, 10) region-specific fixed effects, 11) family background and finally, 12) ability.

<sup>45</sup> Consequently, in this case the new independent variables of the wage regression model are: 1) population of the local labour market, 2) experience\*population, 3) experience(squared)\*population, 4) tenure\*population, 5) tenure(squared)\*population, 6) education\*population, 7) middle school\*population, 8) secondary school\*population, 9) short degree (3 years)\*population and finally, 10) first degree or above\*population. Apart from these determinants, the wage regression model proposed by Di Addario and Patacchini's study includes the following 8 controls which form 7 different model specifications: a) basic controls, b) sector and size of firm, c) type of work-contract, d) occupation, e) non-linear education, f) region-specific fixed effects, g) family background and finally, h) ability.

Then, the findings in terms of the urbanization effects on earnings determinants that **Di Addario and Patacchini, 2008:1056-108**) reveal are: a) urban agglomeration does not generate monetary incentives to invest in either or on-the-job human capital accumulation: a 100000 inhabitant increase in local labor market population returns to experience practically to zero (from 0,011 to 0,018 percent) or returns to tenure in current firm significantly negative (from -0,012 to -0,017 percent), b) the interaction between years of schooling and agglomeration (population) is almost never significant or negatively significant, c) returns to bachelor's degree are systemically negatively correlated with local labour market population size, while returns to middle school is not statistically significant, although it presents a positive association: a 100000 inhabitant increase in local labour market population size reduces college graduates' wages by 0,369 to 0,503 percent. Consequently, the main conclusions that the study carried out by **(Di Addario and Patacchini, 2008)** present are: a) an increase of every additional 100000 inhabitants in the local labor market (an increment of agglomeration economies) raises earnings on average by 0,1 percent and that this effect decays rapidly with distance to the point that beyond approximately 12 kilometers its effect is losing significance and, b) urbanization does not affect returns to experience and that it reduces returns to education and to tenure with current firm.

Briefly, another research that may be interesting to mention, is the study carried out by **(Graham and Kim, 2008)**. Its study proposes an empirical framework for agglomeration economies based on translog production-inverse input demand which can be used to calculate the effect of agglomeration on aggregate wage in 9 industries<sup>46</sup> in the context of 10780 Great Britain wards between the period 1995 and 2002. To do so, Graham and Kim's study estimate an empirical model<sup>47</sup> which is estimated through using a non-linear SURE estimator which is based on two stage procedure: the former estimates the error variance matrix using non-linear least squares and, the latter estimates the parameters that minimizes the generalized sum of the squares for the system as a whole. The results that **(Graham and Kim, 2008:285-286)** points out are related to the fact that agglomeration economies increases labour efficiency, so then it may also raise wages and consequently, higher wages influence on labour demand: a) the estimated coefficients of the agglomeration economies measure (employment density) are statistically significant and positive in 6 out of 9 considered industries, b) construction, business services and public services are negatively associated with wages and finally, c) the economic sectors of distributions, hotels and catering; real estate and; banking, finance and insurance present in this order the highest positive effect on wages, implying an estimated elasticities values of 0,146; 0,111 and, 0,06 respectively. Hence, the main finding that Graham and Kim's study reveals is: as the level of agglomeration changes, also changes the willingness to pay for labour what is clearly consistent with the previous explained studies.

Finally, to conclude this Section 2.2, we will review the works carried out on the one hand, by **(Glaeser and Resseger, 2010)** and on the other by, **(Glaeser et al., 2012)** which are two of the

<sup>46</sup> The 9 industries that the study carried out by (Graham and Kim, 2008) consider are: 1) manufacturing, 2) construction, 3) distributions, hotels and catering, 4) transport, storage and communications, 5) real estate, 6) IT, 7) banking, finance and insurance, 8) business services and, 9) public services.

<sup>47</sup> The non-linear system of equations proposed by (Graham and Kim, 2008) takes the following form: firstly, 1)  $Y = f(L, K, U) + u$ , secondly, 2)  $S_L^C = (\delta \log Y / \delta \log L) / [\delta \log Y / \delta \log L + \delta \log Y / \delta \log K] + v_L$  and finally, 3)  $S_K^C = (\delta \log Y / \delta \log K) / [\delta \log Y / \delta \log L + \delta \log Y / \delta \log K] + v_K$ , where (u,  $v_L$  and,  $v_K$ ) are random error terms that are assumed to be distributed independent of the regressors; (U) represent the total density effect of employment that is accessible to any firm located in ward (i) measured as  $U_i = \frac{E_i}{\sqrt{A_i/\pi}} + \sum_{j \neq i} \left( \frac{E_j}{d_{ij}} \right)$ , where (E) is total employment, ( $A_i$ ) is the area of ward (i) and ( $d_{ij}$ ) is the distance between wards (i) and (j); (L) labour; (K) is capital and finally, ( $S_L^C$ ) and ( $S_K^C$ ) are the cost share form for labour and for capital respectively.

most current relevant studies in the literature because of the in-depth analysis that these two research reveal as regards the complementary between cities, wages and skills as well as their implications in the regional change.

In this sense, the research conducted by (Glaeser and Resseger, 2010) investigate the tendency of more skilled people to live in metropolitan areas through hypothesizing that a) the tendency of more skilled people to live in metropolitan areas might reflect a greater demand of more skilled people for urban amenities and, b) cities disproportionately increase the productivity of more skilled workers. To test it empirically: if this connection reflected a demand for amenities, it would mean that cities are skilled because of abundant labor supply and we should expect to see lower wages for skilled workers in big cities; Glaeser and Resseger's study defines a set of four different wage regression models. The first set of regression model is based on defining as dependent variables a) the logarithm of output per worker, b) logarithm of per capita income and, c) logarithm of median family income next to as explanatory determinants 1) logarithm of population, 2) share of population with a bachelor's degree and, 3) the interaction between population and share of population with a bachelor's degree in which all variables are constructed in 2000 across 335 U.S. metropolitan areas. The second empirical model proposed by (Glaeser and Resseger, 2010) consists of considering an individual-level regression with through using a sample of more than 2 million workers in 2000, the considered dependent variable is logarithm of individual yearly earnings and the explanatory variables are related to: a) metropolitan area size, b) effects of human capital (education and experience) and, c) the interaction between these two determinants<sup>48</sup>. Then, the third set of regression models is focused on estimating the logarithm of real family income across U.S. metropolitan area by using as independent variables, a) the logarithm of population and, b) the share of population with a bachelor degree at the time that is considered two different model samples: 1) across 335 U.S. metropolitan areas, as previously and, 2) across only those areas where the share of population with college degree is greater than 25 percent which implies a sample of the 100 most skilled metropolitan areas. Next to this, the lastly empirical model that Glaeser and Resseger's study defines is focused on a wage model in which the dependent variable is the logarithm of hourly wage in 2000 through using a sample of around 2 million males aged between 25 and 65 years at the time that the determinants are related to a) the location of residence, b) experience dummies, c) education dummies and, d) personal characteristics of the workers<sup>49</sup> in which their combinations determine seven different model specifications<sup>50</sup>.

<sup>48</sup> In this sense, the independent variables that (Glaeser and Resseger, 2010) define are: 1) logarithm of population, 2) percentage of population with a bachelor degree, 3) logarithm of population\*percentage of population with a bachelor degree, 4) logarithm population\*logarithm experience, 5) percentage of population with a bachelor degree\*logarithm of experience, 6) logarithm of population\*percentage of population with a bachelor degree\*logarithm of experience, 7) logarithm of experience and finally, 8) a set of education dummies: 0-9 years, 10-11 years, 13-15 years, 16 years and more than 17 years.

<sup>49</sup> The independent variables that (Glaeser and Resseger, 2010) define are: 1) living in a MSA (metropolitan statistically area), 2) living in a highly educated MSA, 3) living in a low educated MSA, 4) living in a high populated MSA, 5) experience dummies which considers: 0-5 years, 6-10 years, 11-15 years, 16-20 years, 21-25 years, 26-30 years, 31-35 years, 36-40 years and more than 41 years, 6) education dummies which take into account: 0-9 years, 10-11 years, 13-15 years, 16 years and more than 17 years, 7) nonwhite workers and finally, 8) percentage in occupation with bachelor degree.

<sup>50</sup> The model specifications proposed by (Glaeser and Resseger, 2010) are: 1) a basic human capital regression that is defined by including only experience dummies, educational dummies and the characteristics' workers variables, 2) metropolitan areas versus nonmetropolitan area which is included the variable living in a metropolitan area starting from the 1) model specification, 3) highly educated metropolitan area versus nonmetropolitan which includes the variable living in a highly educated MSA apart from the determinants of the 1) model specifications, 4) low educated metropolitan area versus nonmetropolitan area which the explanatory

Hence, the results as regards the first empirical analysis that (Glaeser and Resseger, 2010:224-225) point out are: a) the coefficient of logarithm of population declines slightly from 0,13 to 0,098, roughly a 25 percent decline and consequently, controlling for human capital eliminates about one-quarter of the connection between area population and output per worker, b) there is a positively and statistically significant (with an elasticity of 0,51) on output per worker exerted by the interaction between population and human capital at the time that by including this determinant there are not changes as regards the other determinants' effects: population and human capital are still positively and significant related to output per worker with an elasticities of 0,08 and 1,26 respectively, c) as regards per capita income regression model, the estimated coefficients are 0,026; 1,43 and; 0,42 for population, the share of the population with college degrees and, the interaction correspondingly, and finally, d) if the dependent variable is the median family income, then the estimated elasticities for the mentioned determinants are: 0,019; 1,55 and; 0,36 correspondingly.

Next to the first results, the findings as regards the influence of agglomeration economies and human capital on individual wages that (Glaeser and Resseger, 2010:225-227) reach on are: a) the estimated coefficient of metropolitan area size is positive and statistically significant, measured at 0,041 what implies that the higher the metropolitan size, the higher the annual earnings for a worker, b) this influence is reduced to an elasticity of 0,028 when is controlled by the share of population with college degrees and to 0,022 when is controlled simultaneously by the share of population with bachelor degree and by the interaction between population, c) the interaction between population and experience is negatively and statistically significant associated with annual income on city population with an elasticity value which ranges from -0,004 to -0,007, d) the estimated coefficients of experience which ranges from 0,250 to 0,256 are positively and statistically significant related to wages in all model specifications and finally, e) the model presents that returns to education appear after 13 years of education (an average elasticity of 0,207) and that this effect increases over time (after 17 years of education, the estimated coefficient of this dummy variable is 0,788). Then, the results related to the third set of regression model, (Glaeser and Resseger, 2010:229-230) reveal that: a) while real incomes do not rise with city size, across the entire population (first regression model sample), in these skilled areas (second regression model sample), there is a positive connection (the estimated coefficient of population is 0,025) what entail that, b) there is a greater level of unobserved human capital in these areas or that these bigger cities are particularly unpleasant and higher wages are compensation for negative amenities, c) when is controlled for amenities (temperature), there is no significant change in the results and consequently, is clear that there are more negative amenities in big skilled cities than in big unskilled cities and finally, d) in this sense, the 30 percent of the urban wages coefficient could be explained by human capital (0,025/0,08).

Finally, the main findings as regards the fourth analysis that (Glaeser and Resseger, 2010:236-240) point out are: a) the majority of earnings growth occurs over the first 15 years: *“relative to workers with between 0 and 5 years of experience, workers with between 6 and 10 years of experience earn 0,194 logarithm points higher wages and workers with between 11 and 15 years of experience gain 0,335 logarithm in wages”*, b) the extra gains in wages seem to accrue to metropolitan workers at each experience level: *“metropolitan area workers earn*

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variables are as previously but now including the determinant of living in a low educated MSA, 5) a version of the previous 2 model specifications, 6) highly population versus less populated MSA which includes the independent variable of living in highly populated MSA and finally, 7) high populated metropolitan areas with a highly educated concentration versus less populated metropolitan areas with a highly educated concentration which includes living in a high populated MSA as a specific variable, starting from the 1) model specification.

*a level effect of 0,034 logarithm points more than nonmetro workers at the start of their careers. This gap rises an additional 0,028 logarithm points for workers with between 6 and 10 years of experience. Workers with between 11 and 15 years of experience earn 0,06 logarithm points on top of the level effect, meaning a total premium of 0,096 logarithm points*”, c) working in a highly educated metropolitan statistically area is related to an increase of 0,069 logarithm points in hourly wages compared to working in a low educated metropolitan area which this increment is measured at 0,015 logarithm points, d) residing in a highly populated metropolitan statistically area is positively and statistically significant associated with hourly wages, measured at 0,081 logarithm points more than residing in a less population metropolitan area, e) this is also occurring when a worker is living in highly populated metropolitan area which is highly educated at the same time, in this case the estimated coefficient compared to a less populated metropolitan area with a highly educated workers’ concentration is 0,088 and finally, f) the interaction between skills and metropolitan locations are positive what imply that amenities are not causing that more skilled people decide to locate its residence in large metropolitan areas.

To conclude this Section 2.2 through reviewing the contributions to the literature carried out by the study of (Glaeser et al., 2012), as we mentioned previously, is highly relevant. The main reasons are that this study attempt to analyze in-depth the connection between cities, skills and regional change through quantifying empirically whether the following set of hypothesis as regards the regional decline and resilience are corroborated or not: 1) population patterns have been remarkably persistent over time, 2) population growth persists over short period but not over long periods, 3) Gibrat’s law is often broken, 4) the nineteenth century moved west, the twentieth century moved east, 5) the Great Lakes region grew during two distinct periods, 6) the Sun Belt rose both after 1870 and after 1970, 7) income mean reverts, 8) manufacturing predicts the decline of cities but not the decline of counties, 9) education predicts post-war growth and finally, 10) firm size is strongly correlated with employment and income growth after 1980<sup>51</sup>.

In this sense, to test the seven regional fact, Glaeser’s study estimates a set of four different regression models in which the dependent variable for all of these models is the income growth between 1950 and 1990 at county level and the explanatory variables for each regression are a) January temperature in 1950s, 1960s, 1970s, 1980s and 1990s, b) lagged income for the same years, c) lagged income growth for each considered decade and, d) share of manufacturing respectively. Next to this, its study defines a) set of correlations between the share of the adult population with college degrees and subsequent income growth (with and without considering only counties with more than inhabitants) between the period of 1940s and 1990s at county level and, b) a regression model in which the dependent variable is the income growth between 1950 and 2000 at the time that the explanatory variables are related to a) agglomeration effects, b) amenities, c) human capital effects and, d) initial conditions of income<sup>52</sup>. Finally, (Glaeser et al., 2012) test empirically the fact: firm size is strongly correlated with income growth after 1980 by estimating a regression model in which the dependent variable is the logarithm change in median income between 1980-2000 (with and without only considering counties with 50000 or more inhabitants) and the determinants are

<sup>51</sup> In this Section 2.2, only the hypothesis 7), 9) and 10) are reviewed because of the other ones are not particularly related to the relationship between agglomeration economies and wages and its growth.

<sup>52</sup> The independent variables that (Glaeser et al., 2012) determine are: 1) share of workers in manufacturing 1950, 2) logarithm of population in 1950, 3) mean January temperature, 4) longitude, 5) distance to the centre of the nearest Great Lake, 6) share with a bachelor degree in 1950, 7) logarithm of population\*bachelor degree in 1950 and finally, 8) logarithm of median income in 1950.

referring with a) agglomeration effects (but now by including the additional independent variable as regards firm size effect), b) amenities (natural and weather amenities), c) human capital effects and finally, d) initial conditions of income<sup>53</sup>.

Consequently, the results as regards the former empirical analysis that (Glaeser et al., 2012:10) point out are: a) during every decade expect the 1980s (the estimated coefficient is 0,0904), income growth was substantially lower in places that started with higher income levels, b) in general, this negative relationship between income growth and initial income has become less important: the estimated coefficient was -0,5692 in 1950s, while it was -0,3492 in 1990s and finally, c) since 1980, higher income growth in one decade predicts lower income growth over the next ten years: the estimated coefficient for income growth in 1980s was -0,2839, while the estimated coefficient for the same variable was -0,1966 in 1990s. Next to this, the results related to the hypothesis: education predicts post-war growth that the study carried out by (Glaeser et al., 2012:12-13) has revealed, are: as regards the set of correlations, a) there is a negative relationship between initial education and subsequent income growth: this effect was measured at -0,2517 in 1950s and at -0,2334 in 1990s, b) correlation between income growth and education is always more positive for more population counties (more than 100000 inhabitants): “*in the 1950s and 1960s, when skills were negatively associated with income growth in the entire sample, skills were positively associated with income growth in more populous counties*” what entails that, c) there is a clear complementarity between skills and density; then as regards the regression analysis, d) initial income strongly predicts subsequent income with an estimated coefficient of -0,7392 e) initial population is negatively associated with income growth with an elasticity value of -0,0868, f) proximity to the East Coast, longitude and manufacturing are positively correlated with income growth, while proximity to the Great Lakes is negatively related to income growth and finally, g) education exerts a positive effect on income growth indicating that incomes increases around 7 percent when the interaction between population and education increases 1 standard deviation.

Lastly, the main findings that (Glaeser et al., 2012:15) reach on, as regards the hypothesis: firm size’s effect on income growth, are: a) there is a strong negative connection between average establishment size and income growth: “as average establishment size increases by four, income growth declines by 0,045 logarithm points across the entire sample, and by 0,06 points in the sample of more population counties (more than 50000 inhabitants) however this connection could be understood as, a1) the positive connection between small firm size and later growth as evidence on the value of competition or as, a2) related to the value of local entrepreneurship in the sense that the literature has suggest entrepreneurship as the drivers of change, innovation and productivity growth, b) initial conditions of population, manufacturing concentrations, education (measured as the share of population with a bachelor degree) and distance to the centre of the nearest Great Lake are positively associated with median income growth between 1980 and 2000 (in both samples), although in the case of population, its effect is not statistically significant, also in both model sample and presenting an estimated coefficients of 0,001 and 0,008 respectively, and finally, c) initial conditions of income are negatively and statistically significant related to subsequent income growth with an estimated coefficient of -0,065 when is considered the full sample of counties, while it is positive and not statistically significant (with an elasticity value of 0,062) when is only considered as a model sample those counties with more than 50000 inhabitants.

<sup>53</sup> In this case, the explanatory variables that (Glaeser et al., 2012) define are: 1) share of workers in manufacturing in 1980, 2) logarithm of population in 1980, 3) share with a bachelor’s degree in 1980, 4) distance to the centre of the nearest Great Lake, 5) average establishment size in 1977, 6) logarithm of median income in 1980, 7) longitude and finally, 8) mean January temperature.



### 2.3. Social equity and urban inequality on the basis of wage inequality distribution

In the specialized literature, the debate as regards social equity is often related to the wage inequality distribution at state and region scale. Next to this, the main concept that arises from the literature to capture the dynamics of urban inequality is the idea of convergence. Of course, it has initially focused on across states and regions, although as we previously mentioned in the Introduction, there are recently some studies such as (Wheeler, 2004; Wheeler, 2008; Glaeser, 2000; Glaeser et al., 2008; Glaeser et al., 2009 and; Lee et al., 2013) which have studied urban inequality at local scale.

To explain in detail what convergence idea is based on, perhaps the most meaningful is the work carried out by (Barro and Sala-I-Martin, 1991). In this work, the economic question as regards whether poor countries or regions tend to converge toward rich ones is analyzed firstly across U.S. states through: a) examining the growth and dispersion of personal income since 1880 and relate the patterns for individual states, b) analyzing the interplay between net migration and economic growth and, c) studying the evolution of gross state product (GSP) since 1963 and elate the behavior of aggregate product to productivity in 8 major sectors<sup>54</sup>. Next to this, Barro and Sala-I-Martin's work applies the same framework to the patterns of convergence across 73 regions of Western Europe since 1950. Briefly, the main conclusions of both empirical analyses that Barro and Sala-I-Martin's study reaches on are: a) the overall evidence weighs heavily in favour of convergence, both for sectors and for state aggregates, per capita income and product in poor states tend to grow faster than in rich states and, b) the rate of convergence is however not rapid, the gap between the typical poor and rich both state and regions (in the case of Europe) diminishes at roughly 2 percent a year.

To build on its empirical framework of analysis, (Barro and Sala-I-Martin, 1991) define two different notions of convergence: a) the rate of convergence<sup>55</sup> which relates to poor economies growing faster than rich ones and, b) the dispersion of convergence<sup>56</sup> which refers to the declining over time in the cross-sectional deviation of per capita income or product. Thus, related answering the first research question, (Barro and Sala-I-Martin, 1991:115-121) estimates a) three different specifications of a regression model<sup>57</sup> to examine the convergence

<sup>54</sup> The 8 major sectors that (Barro and Sala-I-Martin, 1991) define are: 1) mining, 2) construction, 3) manufacturing, 4) transportation, 5) wholesale and retail trade, 6) finance, insurance and real estate (FIRE), 7) services and finally, 8) government.

<sup>55</sup> To define, its first notion of convergence, (Barro and Sala-I-Martin, 1991) define the following equation that capture the transitional growth process:  $\left(\frac{1}{T}\right) * \log\left(\frac{y_{it}}{y_{i,t-T}}\right) = x_i^* + \log(\hat{y}_i^*/\hat{y}_{i,t-T}) * (1 - e^{-\beta T})/T + u_{it}$ , where (i) indexes the economy, (t) indexes time, ( $y_{it}$ ) is per capita output (equal to income per person as well as income per worker in the standard model), ( $x_i^*$ ) is the steady-state per capita growth rate, ( $\hat{y}_{i,t}$ ) is the output per effective worker, ( $\hat{y}_i^*$ ) is the steady-state level of output per effective worker, (T) is the length of the observation interval, the coefficient ( $\beta$ ) is the rate of convergence, and ( $u_{it}$ ) is an error term. Hence, in accordance with Barro and Sala-I-Martin's work, the convergence coefficient, ( $\beta$ ) indicates the rate at which ( $\hat{y}_{i,t}$ ) approaches ( $\hat{y}_i^*$ ).

<sup>56</sup> To define, the dispersion of convergence, (Barro and Sala-I-Martin, 1991) start from the equation in which the rate of convergence ( $\beta$ ) is estimated (see, previous cite). From this equation, Barro and Sala-I-Martin's work state that the dispersion of convergence ( $\sigma$ ) declines over time whether the standard deviation diminishes also over time because of in that case is possible to capture the dynamics as regards how the distribution of per capita income across economies have behaved.

<sup>57</sup> The first model specification which define the baseline takes the following form:  $1) \left(\frac{1}{T}\right) * \log\left(\frac{y_{it}}{y_{i,t-T}}\right) = \alpha - [\log(y_{i,t-T})] * (1 - e^{-\beta T}) * \left(\frac{1}{T}\right) + other\ variables$ , where ( $y_{i,t-T}$ ) is the per capita personal income in state (i) at the beginning of the interval divided by the overall CPI (consumer price index); ( $y_{i,t}$ ) is the real per capita personal income in state (i) at time (t); (T) is the length of the observation interval; and the other variables are regional dummies and the following other variables which form the second (2) and the (3) model specification respectively. Thus, the 2) model specification is based on the previous baseline equation with considering

coefficient for nine subperiods<sup>58</sup> of the U.S. states between 1880 and 1988 and, b) the unweighted cross-sectional standard deviation for the logarithm of per capita personal income for 48 U.S. states from 1880 to 1998. The results that its study reaches on are: a) a value of convergence coefficient approximated at 2 percent a year, when is constrained its estimation to be the same for all subperiods, this implies that poor economies grow faster than the rich ones, b) when are included regional dummies, then the coefficient of convergence diminishes to 0,0189 (1,89%), c) the joint estimate for the nine subperiods when are included other control variables, is 0,0024 and as a consequence, d) in all three specification the convergence hypothesis is corroborated at a rate somewhat above 2 percent a year, e) the dispersion of personal income declined from 0,54 in 1880 to 0,33 in 1920, but then rose to 0,40 in 1930, f) after 1930, the indicator of the dispersion fell to 0,35 in 1940, 0,24 in 1950, 0,21 in 1960 to the lowest point of 0,14 in 1976 however since then, g) it rose to 0,19 in 1988.

Next to this, as regards the second research question, (Barro and Sala-I-Martin, 1991:129-133) estimate four different specifications of a regression model<sup>59</sup> to investigate whether people are motivated to move from low-wage to high-wage areas for eight subperiods (compared to previously, now the first time sub-period starts in 1900-1920) of the U.S. states between 1900 and 1988. The findings that Barro and Sala-I-Martin's work reveals are: a) the estimated coefficients of heating-degree days are all negative and most are significantly different from zero and consequently, this indicates that people prefer warmer states, b) for population density and population density (square), the negative coefficient of -0,0452 and the positive one of 0,0340 respectively, imply that the marginal effect of population density on in-migration is negative, c) the positive and highly significant relationship between the rate of in-migration and lagged per capita income; d) the estimated coefficient of convergence rate without migration is between 0,014 and 0,016 instead of 0,0210 and as result, this implies that migration can account for as much as a third of the estimated rate of convergence whether there is no human capital of migrants, e) when the net migration rates is constant, then the rate of convergence is 0,0250 which is exactly 0,0027 points more than when the migration rate is excluded and consequently, f) the shifts in net migration rates do not have a strong interaction with per capita growth: if the net migration rates constant, the estimation of the convergence rate is quite similar 0,0250 versus 0,0210.

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regional dummies. Next to this, the 3) model specification is based on the baseline equation and including the following other explanatory variables: a) the share of personal income originating in agriculture at the start of the period and, b) the structure composition variable which is measured as  $S_{it} = \sum_{j=1}^9 w_{ij,t-T} * \log(y_{jt}/y_{j,t-T})$ , where ( $w_{ij,t-T}$ ) is the weight of the sector (j) in state i's personal income at time (t-T), and ( $y_{jt}$ ) is the national average of personal income in sector (j) at time (t), expressed as a ratio to national population at time (t).

<sup>58</sup> The nine sub-periods that the work carried out by (Barro and Sala-I-Martin, 1991) define are: 1) 1880-1900, 2) 1900-20, 3) 1920-30, 4) 1930-40, 5) 1940-50, 6) 1950-60, 7) 1960-70, 8) 1970-80 and, 9) 1980-88

<sup>59</sup> In these four different model specifications, proposed by (Barro and Sala-I-Martin, 1991) the dependent variable is the ratio of migrants (annual average over each subperiod) to state population at the start of subperiod in order to it could approximate the contribution of net migration to the state's rate of population growth over the subperiod. Consequently, the baseline model, that its study proposes is the following one: 1)  $m_{it} = \alpha + b \log(y_{i,t-T}) + c_1 \log(Heat_i) + c_2 \pi_{i,t-T} + c_3 (\pi_{i,t-T})^2 + other\ variables$ , where ( $y_{i,t-T}$ ) is the real per capita personal income at the beginning of the subperiod, ( $Heat_i$ ) is the average number of heating-degree days for state (i), formed as an average for available cities in the state, ( $\pi_{i,t-T}$ ) is the population density measured as thousands of people per square mile of area of state (i) at the beginning of the subperiod; and the other variables are regional dummies, the share of agriculture in personal income and as previously, the sectoral composition variable. Next to this, the 2) second specification of the model is based on using heating-degree days in the regression. Then, the 3) third one is based on constraining population density to be the same for all considered 8 subperiods. Finally, the 4) last model specification is based on considering that square of population density is constrained to be the same for all subperiods.

Then, in terms of the convergence process and gross state product (GSP) for 48 U.S. states, considering the whole economy and the aforementioned eight different sectors, the study carried out by (Barro and Sala-I-Martin, 1991:136) estimate again three specifications of a regression model<sup>60</sup> to analyze this dynamic between the time period of 1963 and 1986 considering four different subperiods<sup>61</sup>. The results that its study points out are: a) the results on the estimated coefficient of convergence for GSP (gross state product) are similar to those for personal income, meaning that the joint estimation of convergence (considering the four subperiod simultaneously) expels a value of 0,0216; next to this, as regards the sectoral analysis, b) the results reveals positive estimates of the convergence coefficient for each of the 8 considered sectors, although not all of the estimates are statistically significant, c) service-type sectors tends to have less convergence process than the manufacture sector: the former sectors its value of the coefficient convergence ranges between 0,009 to 0,016, while in the case of manufacturing sector, the coefficient is 0,0460 and consequently, d) although the joint estimate of convergence coefficient is 0,0213, there is a rejection at 5 percent level of the hypothesis that the convergence coefficient for each sector is the same (across sectors).

Finally, the results that (Barro and Sala-I-Martin, 1991:142-146) reach on as regards the analysis of the convergence process<sup>62</sup> across 73 regions in Europe<sup>63</sup> are: a) there is also a type of negative relation as similar as the study of the U.S. states in which the correlation between the growth rate and the logarithm of initial per capita GDP (gross domestic product) is -0,70, b) all convergence coefficients are positive indicating that there has been a process focused on that poorer region in countries tend to grow faster than the richer ones, c) the estimated coefficients of convergence reveals the acceptance of the hypothesis of stability at the 5

<sup>60</sup> The baseline model that (Barro and Sala-I-Martin, 1991:137) take the following form:  $\left(\frac{1}{T}\right) * \log\left(\frac{y_{it}}{y_{i,t-T}}\right) = \alpha - [\log(y_{i,t-T})] * (1 - e^{-\beta T}) * \left(\frac{1}{T}\right) + other\ variables$ , where  $(y_{i,t-T})$  is per capita gross product (GSP), divided by the national deflator for GSP at time (t); (T) is the length of the interval; and the other variables are regional dummies and the structural composition variable. The second specification of the aggregate GSP regression model takes into account regional dummies and the third one, on its turn considers regional dummies and sectoral variables which are the aforementioned ones (see, cite 35). Next to this, when is considered 8 different sectors, the baseline model that the study carried out by Barro and Sala-I-Martin define is the same as previously but only considering in this case, regional dummies as other variables:  $\left(\frac{1}{T}\right) * \log\left(\frac{y_{it}}{y_{i,t-T}}\right) = \alpha - [\log(y_{i,t-T})] * (1 - e^{-\beta T}) * \left(\frac{1}{T}\right) + regional\ dummies$ , where  $(y_{it})$  is the ratio of the sector's contribution to state i's gross state product (GSP) to the employment in the sector for that state at time (t), with (T) equal to 23 years (between 1963 and 1986).

<sup>61</sup> The four subperiods considered by (Barro and Sala-I-Martin, 1991) are: 1) 1963-69, 2) 1969-75, 3) 1975-81 and finally, 4) 1981-86.

<sup>62</sup> To carry out this analysis, Barro and Sala-I-Martin's study defines two approaches. The former is related to examining the relationship between the growth rate of per capita GDP (gross domestic product) from 1950 to 1985 to the logarithm of per capita GDP in 1950 for these aforementioned European regions. The latter is based on estimating a regression model for GDP across European regions between the period 1950 and 1985 considering three different model specifications and four different subperiods (1950-60, 1960-70, 1970-80 and, 1980-85). In this sense, the baseline of the regression model proposed by (Barro and Sala-I-Martin, 1991:146) takes the following form:  $\left(\frac{1}{T}\right) * \log\left(\frac{y_{it}}{y_{i,t-T}}\right) = \alpha - [\log(y_{i,t-T})] * (1 - e^{-\beta T}) * \left(\frac{1}{T}\right) + other\ variables$ , where  $(y_{i,t-T})$  is per capita gross domestic product (GDP) in region (i) at the beginning of the subperiod,  $(y_{it})$  is per capita GDP at time (t); (T) is the length of the interval, and the other variables are country dummies and the shares of agriculture and industry in employment or GDP at the start of the time period. Next to this, its study defines the second model specification by including country dummies, and the third one by including country dummies and structural variables.

<sup>63</sup> These 71 European regions are divided into: 11 in Germany, 20 in Italy, 4 in the Netherlands, 3 in Denmark, 11 in the United Kingdom, 21 in France and finally, 3 in Belgium.

percent level, d) the joint estimate of the convergence coefficient is 0,0178 which is quite low compared to the corresponding value, around 0,002 found for the U.S. states.

Consequently, the main contributions of the pioneer work carried out by (Barro and Sala-I-Martin, 1991) in brief are: a) there is ample evidence that poor states in U.S. and poor regions in Europe tend to grow faster than richer states and regions respectively and, b) this dynamic of convergence is approximated to be a 2 percent per year. Apart from this study, maybe another relevant work as regards convergence process but now focusing on the metropolitan scale is the study of (Berry and Glaeser, 2005). This study presents a model where the clustering of skilled people in metropolitan areas is driven by the tendency of skilled entrepreneurs to innovate in ways that employ other skilled people and by the elasticity of housing supply<sup>64</sup> with the objective to investigate a) whether there is an end of regional convergence (the declining of income across metropolitan areas)<sup>65</sup> and, b) if it is related to the divergence of skill levels across the metropolitan space. Berry and Glaeser's study is relevant in two ways: a) provides a theoretical framework to understand the convergence process at metropolitan scale rather than the state and regional one and, b) build a frame of analysis without considering the influence of built environment variables (e.g. population density) that the following analyzed works in this Section 2.3.

Therefore, the results that (Berry and Glaeser, 2005) have revealed are: there is a substantial convergence in the 1970s which has decreased over time, a) the coefficient on initial income as regards wage models without taking into account human capital effects, is -0,06 in the 1970s and 0,02 in the 1990s, so moving from being significantly negative to being positive and significant, b) the coefficient on initial income related to income models also without controlling for human capital is -0,11 in the 1970s and positive but not statistically significant in the 1990s, as a consequence the regression models has shown that, c) *“in the 1970s, poorer metropolitan areas were getting richer relative to richer metropolitan areas. In the 1990s, richer areas got richer relative to poorer areas”*; next to this, when is controlled for human capital in the metropolitan then, d) there is a still a substantial decline in the level of convergence, although as regards income regression this reduction is less important: in the wage models, the coefficient of initial conditions is -0,074 in the 1970s and -0,001 in the 1990s, compared to -0,150 in the 1970s and -0,090 in the 1990s as regards income regression models. All of these results explain why convergence has been declined at metropolitan scale, at least in the United States context over the last 30 years: *“one potential reason for this is that initial high income, and high skill, places are increasingly attracting more skilled people.*

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<sup>64</sup> According to what (Berry and Glaeser, 2005:408) have stated: *“the core assumption of the model is that the number of entrepreneurs is a function of the number of skilled (and unskilled) people working in an area. This model departs from traditional regional models by assuming that new entrepreneurs are, at least for a time, relatively immobile. If skilled people are more likely to innovate in ways that employ other skilled people then this creates an agglomeration economy where skilled people want to be around each other”*.

<sup>65</sup> To do so, (Berry and Glaeser:2005) define the following basic convergence regression:  $\log\left(\frac{MSA\ Income_t}{MSA\ Income_{t-1}}\right) = \alpha + \beta * \log(MSA\ Income_{t-1}) + other\ controls$ , where income in time (t) and (t-1) is defined through a) logarithm change in average wage between 1970-80, 1980-90 and, 1990-2000 and, b) logarithm change in per capita income also within the aforementioned three different subperiods;  $(MSA\ Income_{t-1})$  is the initial conditions of the two different measures of income respectively; and other controls are related to control for human capital on the basis of measuring the adults with college degree. Hence, at the end (Berry and Glaeser) estimate two sets of convergence regression models across 318 MSA (metropolitan statistical areas). The former set without considering the effect of human capital on metropolitan convergence and the latter with taking into account these effects. Next to this, in each of the sets, according to (Berry and Glaeser, 2005:433-434), the estimation process is carried out through using both measures of income and for each of the time subperiods.

*When we control for the changes in the skill composition at the area level, convergence reappears although there still seems to be some change between 1970 and 2000”.*

In this sense, one of the most relevant studies in the literature that attempt to analyze convergence process in metropolitan areas apart from the empirical relationship between growth and wages, is the research conducted by (Wheeler, 2004). This study investigates the relationship between the growth of three measures of economic activity: a) population, b) employment, and c) per capita income and; a variety of wage-dispersion measures: 1) overall inequality, 2) between-education-group inequality and 3) residual inequality (within-group)<sup>66</sup> across a sample of U.S. metropolitan areas between 1970 and 1990 (the spatial unit that Wheeler’s study uses is the metropolitan statistical areas: in 1970’s sample, are used 103 MSAs, in 1980’s sample are defined 220 MSAs and finally in 1990’s sample are used 226 MSAs out of 275 respectively). Briefly, Wheeler’s study reaches on the conclusion that there is a negative connection between the two: cities experiencing more rapid growth also tend to witness smaller increases (or larger decreases) in their inequality what supports the growth-mechanisms on the basis of the convergence paradigm.

To test it empirically in detail, on the one hand (Wheeler, 2004) estimates a three sets regression models by using GLE (generalized/weighted least squares) and 2SLS (two-step least squares) with instruments variables<sup>67</sup> in which the dependent variables are a) overall inequality<sup>68</sup>, b) between-education-group inequality<sup>69</sup> and, c) within-group (residual)

<sup>66</sup> According to the Wheeler’s study, the three wage-dispersion measures are defined as following: 1) overall inequality, defined as the difference between 90<sup>th</sup> and 10<sup>th</sup> percentiles of the logarithm weekly wage distribution, 2) between-education-group inequality, which captures the differences in the estimated coefficients on a set of education dummies from city-specific regressions of wages on education and experience, and finally, 3) residual inequality (within-group inequality), defined as 90<sup>th</sup> and 10<sup>th</sup> differences in the residuals from these regressions.

<sup>67</sup> To mitigate the possible endogeneity that may arise in the wage inequality equations estimated by GLS techniques with a lag of 10 years, (Wheeler, 2004:385) defines the following instruments variables: 1) logarithm of initial population and, 2) logarithm of employment density as instruments for population and employment growth; lastly, 3) logarithm per capita income which is an instrument for per capita income growth.

<sup>68</sup> Starting from the following characterization of earnings in a city economy in which wage of the worker situated at percentile (p) in city (c) at time (t), ( $w_{ct}^p$ ) be given as follows:  $w_{ct}^p = \exp(\mu_c^p + \delta_t^p + \phi^p \log(N_{ct}) + \gamma^p Z_{ct} + \epsilon_{ct}^p)$ , where ( $\mu_c^p$ ) is a time-invariant constant specific to percentile (p) of city (c), designed to capture the average characteristics (e.g. human capital, skill, ability) of the workers situated at this city-percentile; ( $\delta_t^p$ ) is a time effect common to all workers at this percentile in year (t); ( $N_{ct}$ ) is the size (i.e. population, employment, or per capita income) of city (c) at time (t); ( $Z_{ct}$ ) is a vector of additional city-level covariates influencing labor earnings; and ( $\epsilon_{ct}^p$ ) is a city-time-percentile specific residual; (Wheeler, 2004:377) define the following equation to be estimated by using GLS techniques and taking 10-year differences:  $\Delta(\log(w_{ct}^{90}) - \log(w_{ct}^{10})) = \Delta\delta_t + \phi[\Delta \log(N_{ct})] + \gamma[\Delta Z_{ct}^t] + \Delta\epsilon_{ct}$ , in which these three vectors are further augmented with regional dummies to assess the robustness of the estimated coefficients to geographic differences in the rates at which inequality has changed: U.S. Census regions classified into 1) west, 2) midwest, 3) northeast and finally, 4) south.

<sup>69</sup> To examine the between-education-group inequality, (Wheeler, 2004:388) follows two-step procedure. Firstly, Wheeler’s study estimates a regression in which logarithm weekly wages for individual (i), in city (c) at time (t) is expressed as follows:  $\log(w_{ict}) = \beta_{ct} X_{ict} + \sum_{j=1}^5 \theta_{ct}^j E_{ict}^j + \xi_{ict}$ , where ( $X_{ict}$ ) is a vector of personal characteristics consisting of an indicator for marital status and fourth-order polynomial in potential experience, the five ( $E^j$ ) terms represent educational attainment dummies (no high school, some high school, high school, some degree and, college degree or more); and ( $\xi_{ict}$ ) is a person-city-time-specific residual. Next to this, the second step of Wheeler’s procedure is focused on constructing four between-education group premia based on the aforementioned five  $\theta$  terms, which capture the average weekly wage earnings for individuals of a given educational group in a particular city-year, conditional on a flexible polynomial in experience as follows: 1) college-some college ( $\hat{\theta}_{ct}^5 - \hat{\theta}_{ct}^4$ ), 2) college-high school ( $\hat{\theta}_{ct}^5 - \hat{\theta}_{ct}^3$ ), 3) college-some high school ( $\hat{\theta}_{ct}^5 - \hat{\theta}_{ct}^2$ ), and lastly, 4) college-no high school ( $\hat{\theta}_{ct}^5 - \hat{\theta}_{ct}^1$ ).

inequality<sup>70</sup>. In addition, in accordance with Wheeler’s empirical framework, each set of regression models are connected with the three aforementioned growth measures: 1) population growth, 2) employment growth and, 3) per capita income growth which conjointly with other explanatory variables<sup>71</sup> define a set of sub-regression models, three for each mentioned inequality dependent variable. Next to this, on the other hand, Wheeler’s study attempts to examine the convergence process across U.S. metropolitan areas between the time period of 1970 and 1990. In particular, (Wheeler, 2004) investigates whether there is any evidence that the urban growth process has brought U.S. metropolitan areas to a common level of wage inequality by considering both notions of convergence<sup>72</sup>.

As regards the first set of regression models, the work of (Wheeler, 2004:379-381) reaches on the following results: a) the effect of union is associated with greater wage dispersion: “*the estimated coefficients are negative, and in two instances, statistically non-zero at conventional levels*”, b) foreign-rate (population born outside the national territory) is positively and statistically significant associated with earnings inequality, c) increases in earnings inequality is linked to a decrease in manufacturing’s presence in total employment: “*four of the six estimated coefficients are negative, although only those appearing in the per capita income growth equations are significant*”, d) unemployment rate do not exert any kind of influence (the coefficient is statistically not significant) on the earnings inequality, e) the effects of human capital (education) is mostly insignificant and change its influence (sign) depending on the considered model: in particular, the coefficients are negative in the population and employment growth sub-models, and positive as regards the income growth sub-model, f) growth effects (population, employment and income) are negatively and statistically significant associated with earnings inequality: “*for example the estimates suggest that a 10 percentage point increase in population or employment growth –approximately, a one standard deviation increase- corresponds to, roughly a 3 to 4 percentage point decrease in the difference between the 90<sup>th</sup> and 10<sup>th</sup> percentiles of the logarithm weekly wage distribution*” and “*the implied connection is even stronger for per capita income growth: a 10*

<sup>70</sup> As regards within-group (residual) inequality, (Wheeler, 2004:388) computes the difference between the 90<sup>th</sup> and 10<sup>th</sup> percentiles of the distribution of residuals ( $\xi_{ict}$ , see the previous cite). Hence, the residual inequality is modeled as follows:  $(\xi_{ct}^{90} - \xi_{ct}^{10}) = \mu_c + \delta_t + \phi \log(N_{ct}) + \gamma Z_{ct} + \epsilon_{ct}$ , where as the Wheeler’s overall inequality equation, now the estimation procedure also uses 10-year differences to eliminate the city-specific intercepts ( $\mu_c$ )

<sup>71</sup> The explanatory variables that the study carried out by (Wheeler, 2004) defines at metropolitan area level are constructed from data collected at county level. In this sense, these determinants are: 1) TOTAL RESIDENT POPULATION, 2) TOTAL EMPLOYMENT, 3) PER CAPITA INCOME, 4) PERCENTAGE OF THE ADULT POPULATION (+25 years) WITH AT LEAST A COLLEGE DEGREE, 5) PERCENTAGE OF TOTAL EMPLOYMENT IN MANUFACTURING, 6) UNEMPLOYMENT RATE, 7) POPULATION DENSITY which are calculated as the ratio of city-level population to total city-level land area (in square miles), 8) EMPLOYMENT DENSITY which is measured as the ratio of city-level employment to total city-level land area (in square miles), 9) FOREIGN-BORN which is calculated as the percentage of the population that is foreign-born, and finally, 10) UNION which is measured as the percentage of the workforce that belongs to union.

<sup>72</sup> Therefore, (Wheeler, 2004:391) consider 1) the first notion of convergence which implies that, cities with different levels of inequality converge to a common level and so consequently, there will be a negative association between initial inequality and the magnitude of its subsequent change and, 2) the second notion of convergence in which implies that whether cities are converging to a common level of inequality, the cross-sectional standard deviation of inequality levels should be decreasing over time. To do so, Wheeler’s study examines the first notion of convergence by estimating the following three regression models (in which the coefficient  $\beta$  should be significantly negative): 1) for overall wage differentials,  $\Delta(\log(w_{ct}^{90}) - \log(w_{ct}^{10})) = \alpha + \delta_t + \beta[\log(w_{ct-1}^{90}) - \log(w_{ct-1}^{10})] + \epsilon_{ct}$ , 2) for the relative education premia,  $\Delta(\hat{\theta}_{ct}^5 - \hat{\theta}_{ct}^j) = \alpha^j + \delta_t^j + \beta^j[\hat{\theta}_{ct-1}^5 - \hat{\theta}_{ct-1}^j] + \epsilon_{ct}^j$  where  $j=1, \dots, 4$ ; and finally, 3) for the residual measure,  $\Delta(\xi_{ct}^{90} - \xi_{ct}^{10}) = \alpha + \delta_t + \beta[\xi_{ct-1}^{90} - \xi_{ct-1}^{10}] + \epsilon_{ct}$ . Next to this, the second notion of convergence is analyzed by (Wheeler, 2004) through estimating standard deviation for each of the aforementioned inequality measures between 1970 and 1990.

*percentage point rise in growth is accompanied by a 6 to 7 percentage point drop in inequality*”; then, when these previous models are estimated through using instruments variables instead of GLS techniques, the results are: g) in general the instrument estimates are larger compared to the GLS ones: *“for example, whereas the previous estimates indicated that in response to a 10 percentage point increase in either population or employment growth, inequality dropped by between 3 and 4 percentage points (6 to 7 percentage points for per capita income growth), the TSLS estimates imply a 4 to 5 percentage point drop in inequality (9 to 11 percentage points for per capita income)”*, and lastly, h) although two coefficients of income growth are statistically insignificant (when is not controlled for other determinants, both with and without regional effects), the other coefficients as regards income growth and the coefficients related to population and employment growth are still negative and statistically significant; consequently, growth is still remaining negatively associated with earnings inequality.

Then, as related to the second group of regression models on the basis of examining the between-education-group inequality, the results that (Wheeler, 2004:388-389) points out are: a) although, there are some coefficients that are not statistically significant; in general, the evidence suggest that there is an inverse (negative) relationship between growth (population, employment and income) and between-skill-group inequality (strongly as regards per capita income growth rather than employment growth and population growth respectively: all coefficients of per capita income growth are statistically significant, while the coefficients of the population and employment growth are significant only around 30% of the cases; consequently, b) the strongest results emerge when per capita income growth and their results in this case are proportional: *“a 10 percentage point increase in per capita income growth is associated with a 3 percentage point drop in the college-some college differential; a 4 to 7 percentage point drop in either the college-high school or college-some high school differential; and an 8 to 12 percentage point decrease in the college-no high school gap”*, and finally, c) employment growth appears to be the more relevant variable for explaining changes in between-education groups inequality compared to the population one: *“the 16 coefficients, 10 are statistically non-zero at 10 percent significance, and among these, the magnitudes are fairly consistent, suggesting a 1 to 4 percentage point drop in the between-education-group gaps given a 10 percentage point increase in growth. Changes in population, for the most part, do not appear to have particularly strong connection to most of the between-education-group gaps, as only five of the coefficients are significant”*.

Next to this, in terms of within-group inequality results, (Wheeler, 2004:390) reveal that: a) compared to previously, now the strongest influence arise from increases in population and employment growth respectively: *“the coefficients on these two series is significantly negative: the magnitudes, in this cases, suggest that 10 percentage point rise in growth is accompanied by a 1 to 3 percentage point decrease in residual 90-10 wage difference”*, while b) the relationship between residual inequality and per capita income growth is weak: only the regression models using instruments variables reveals a statistically significant coefficient.

Finally, the result that (Wheeler, 2004:392-394) reaches on analyzing the two aforementioned notions of convergence are: a) all wage dispersion variables shows some tendency to convergence to a common level (the estimated coefficients are significantly negative) with the exception of the college-no high school wage differential when region effects are excluded from the regression because of its coefficient, although it is negative, it is not significant, and in the case of the overall 90<sup>th</sup> percentile (its coefficient is positive and not statistically significant), consequently; b) convergence in this measure of dispersion has been

driven by adjustment at the bottom end of the distribution: low 10<sup>th</sup> percentiles “catching up” to high 10<sup>th</sup> percentiles and lastly, when is analyzed the evolution of the cross-sectional standard deviation of certain measures of inequality between 1970 and 1990, c) although, there is a clear evidence of a declining between 1970 and 1980 of the standard deviation values as regards certain inequality measures: for example, overall and residual differentials and percentiles, and the absolute education return, they all have risen since then: for instance; in the case of the overall 90<sup>th</sup> and 10<sup>th</sup> percentile (the most favorable convergence measure), its standard deviation value was around 0,093 and 0,124 in 1980 respectively, and 0,139 and 0,141 in 1990 correspondingly.

Consequently, the main contributions to the literature that (Wheeler, 2004) has made are: a) per capita income growth seem to reduce overall wage dispersion primarily through a between-skill-group channel, b) growth in population, appears to be the result of mechanisms that reduce wage inequality predominantly within skill groups, c) employment growth seems to involve aspects of each type: appears to have a fairly significant tie to both measures of inequality (overall, between-skill-group and within inequality) and finally, d) the statistically estimates (in general, 90<sup>th</sup>-10<sup>th</sup> gap) suggest that a 10 percentage point increase in a city’s rate of population and employment growth, for example, is accompanied by a 3 to 5 percentage point decrease, and; the estimated effect of per capita income growth is even stronger, implying a 5 to 11 percentage point drop in inequality.

An extension of the work carried out by (Wheeler, 2004), is the research conducted by the same author in (Wheeler, 2008) in which examines whether urban density impact on the degree of income inequality within U.S. metropolitan areas by using a data based on 165000 block groups (on average of 526,5 households for each block group) across 359 metropolitan areas in the sample of 1980, 1990 and 2000. In addition, Wheeler’s study investigates this relationship at census tract scale (on average of 1648,8 households for each census tract). To test it empirically, (Wheeler, 2008) construct its empirical framework on the basis of analyzing 1) the metropolitan area income versus population density<sup>73</sup>, 2) the decomposition of this metropolitan area income into within- and between- neighbourhood income inequality<sup>74</sup>, 3) the analysis of other measures of between-neighbourhood inequality focused on the differences in 90<sup>th</sup>, 50<sup>th</sup> and, 10<sup>th</sup> percentiles of the average household income distribution within each metropolitan areas<sup>75</sup> and finally, 4) the inequality within and between tracts<sup>76</sup>.

<sup>73</sup> In this sense, (Wheeler, 2008:45) define the following equation which is taken 10-year differences, to eliminate the metro area fixed effects:  $\Delta\sigma_{mt}^2 = \Delta\mu_t + \beta\Delta X_{mt} + \gamma\Delta D_{mt} + \Delta\varepsilon_{mt}$ , where ( $\mu_t$ ) is a year-specific term, ( $X_{mt}$ ) is a vector of covariates (basic characteristics commonly associated with the degree of income inequality in an economy), ( $D_{mt}$ ) is the logarithm of population density and, ( $\varepsilon_{mt}$ ) is a residual.

<sup>74</sup> By considering that the variance of household income in a metropolitan, ( $\sigma^2$ ), can be estimated as:  $\sigma^2 = \frac{1}{H} \sum_{n=1}^N \sum_{h=1}^{H_n} (y_{h,n} - \bar{y})^2$  where, ( $y_{h,n}$ ) is the income household (h) of neighbourhood n, ( $\bar{y}$ ) is the mean household income for the entire metropolitan area, ( $H_n$ ) is the total number of households in neighbourhood (n), (N) is the total number of neighbourhoods, and (H) is the total number of households; (Wheeler, 2008:48) rewrites the expression in the following way, which is consisting of two terms:  $\sigma^2 = \frac{1}{H} \sum_{n=1}^N \sum_{h=1}^{H_n} (y_{h,n} - \bar{y})^2 + \frac{1}{H} \sum_{n=1}^N \sum_{h=1}^{H_n} (\bar{y}_n - \bar{Y})^2$ , where ( $\bar{y}_n$ ) represents the mean household income in neighbourhood (n), the first of the terms on the right-hand side of the previous equation is the “within” neighbourhood component, which measures the degree of income dispersion households within the same neighbourhood, and the second term, the “between” component, captures the amount of income variation across different neighbourhoods.

<sup>75</sup> Wheeler’s study defines two types of regression models. The former, the dependent variables (percentiles) are computed in a weighted way (where the weights are given by the number of households in each block group). Next to this, in the latter type, the percentiles are calculated in an unweighted way. In addition, both of these two kinds of regression models are estimated 1) by considering the three aforementioned specifications and, 2) by using OLS techniques and by considering the two instruments variables (density and industry shares). Hence, the



The results of the first perspective of analysis that (Wheeler, 2008:45-47) obtains by estimating three different specifications of its baseline model taking into account explanatory variables as regards city size (population density) and other commonly characteristics<sup>77</sup>, are: a) larger proportions of women and individuals younger than age 24 in the local population are strongly, positively associated with inequality, b) inequality increases with the percentages of foreign-born residents and individuals older than age 65 in the local population, although the models reveals that not always this relationship is statistically significant, c) metropolitan area's inequality tends to rise significantly as the unemployment rate increases, d) inequality is negatively and statistically significant associated with the extent of union coverage in the local labor force (union contracts tend to equalize earnings across workers), e) the sectors of manufacturing; construction; finance, insurance, and real estate; public administration and; education services are significantly, and negatively associated with inequality (the others considered sectors do not exert any kind of significant influence), f) population density is uniformly negative and statistically significant across all three specifications: *“a 1 standard-deviation increase in the change in population density corresponds to a 1 log point increase in the change in log income variance, representing approximately 20 percent of the mean change in log income variance”*.

The findings as regards the second income analysis that (Wheeler, 2008:48-50) reaches on are: on the one hand, as regards within-neighbourhoods, a) the change in a metropolitan area's degree of income variation within its block groups is positively and significantly tied to changes in the fraction of the population with a bachelor's degree, the fraction that is black, and the fraction that is foreign-born, b) increases in the percentages of total employment in

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six dependent variables that (Wheeler, 2008:52) defines are: a) unweighted 90-10 percentile difference, b) unweighted 90-50 percentile difference, c) unweighted 50-10 percentile difference, d) weighted 90-10 percentile difference, e) weighted 90-50 percentile difference and, f) weighted 50-10 percentile difference.

<sup>76</sup> In such empirical analysis, (Wheeler, 2008) carries out the same research strategy applied in the previous three perspective. Hence, the regression models are estimated through using OLS techniques and instruments variables (density and industry shares), each type of regression models consist of three different specification in order to guarantee its robustness, the explanatory variables are the population density and the aforementioned control characteristics, and finally, the dependent variables of each considered regression model are: 1) within component, 2) between component, 3) unweighted 90-10 percentile difference, 4) unweighted 90-50 percentile difference, 5) unweighted 50-10 percentile difference, 6) weighted 90-10 percentile difference, 7) weighted 90-50 percentile difference, 8) weighted 50-10 percentile difference, 9) unweighted 90<sup>th</sup> percentile, 10) unweighted 50<sup>th</sup> percentile, 11) unweighted 10<sup>th</sup> percentile, 12) weighted 90<sup>th</sup> percentile, 13) weighted 50<sup>th</sup> percentile and finally, 14) weighted 10<sup>th</sup> percentile.

<sup>77</sup> To guarantee the robustness of the density-inequality relationship (Wheeler, 2008) define the following three specification of its baseline model: 1) the first limits the regressors to logarithm of density, the three region dummies and a time effect for the 1980-1990 decade, 2) the second adds the population demographics of each metropolitan area (age, race, gender, education, foreign-born status) and, 3) the third includes the basic characteristics of a metropolitan area's labor market (industry employment shares, unionization and unemployment). In addition, these three different specifications are in accordance with the covariates characteristics included in the Wheeler's baseline model, which is presented in the previous cite. Hence, the explanatory variables that (Wheeler, 2008) define apart from a) POPULATION DENSITY which is calculated according to Wheeler's study for each metropolitan area as the weighted average of county-level population densities, where the weights are given by each county's share of total metropolitan area population (in this sense is possible to mitigate the influence of extremely large but relatively unpopulated counties, when is calculated population density as the ratio of total metropolitan area population to total land area), are: b) the percentage of the resident population that are BLACK, c) FEMALE, d) FOREIGN-BORN, e) YOUNGER THAN THE AGE 25, f) OLDER THAN AGE 65, g) the fraction of the population 25 years of age or older that has completed at least a BACHELOR'S DEGREE, h) SHARES OF EMPLOYMENT IN 9 BROAD INDUSTRIES (manufacturing; agriculture, forestry, fishing and mining; construction; wholesale trade; retail trade; finance, insurance, and real estate; public administration; education services; health services), i) the fraction of the labor force that is represented by a UNION, j) the unemployment rate, and finally, k) three REGIONAL DUMMIES to account for any basic geographic differences in the inequality trends across different parts of the country.

manufacturing; finance, insurance, and real estate correlate negatively with income inequality within neighbourhoods (other considered sectors, its impact is not significant); c) the results of population density, are clear, there is a negative association with the extent of income variation within neighbourhoods: *“as the change in population density increases by 1 standard-deviation, the change in log income variance within block groups increases by approximately 1 percentage point”* then, on the other hand, related to between-neighbourhoods, d) there is a similar positive and significant association with the fraction of college graduates in the local population, e) increases in the percentages of the population that accounts for by women, individuals younger than age 24, and the unemployment rate tend to be associated with increases in the extent of income variation between different block groups, f) between-neighbourhood inequality is significantly, negatively tied to the fraction of the local population that is black, the shares of total employment that accounts for by construction and education services, and the extent of union representation in the local labor force, and finally, g) the estimated association between density and between-neighbourhood inequality is extremely small: *“none of the three specifications produces a statistically significant coefficient on the change in population density. Thus, there is a little evidence that urban decentralization is associated with rising income differentials between neighbourhoods”*.

Then, these two approaches are checked by (Wheeler, 2008:50) through estimating the same regression models by using instrumental variables estimates<sup>78</sup> in order to mitigate the potential endogeneity of changes in density with respect to changes in inequality. In this sense, the results that Wheeler’s study has achieved are: a) in general, the estimates as regards population density are very similar that the coefficients obtained in its first and second analysis: density and inequality are negatively related, and the association operates primarily through a within-neighbourhood channel rather than a between-neighbourhood control and, b) the elasticities of using density in 1980 as instruments variables are high compared to the elasticities obtained by using industries shares in 1980 as a instrument variable. Next to this, as regards the analysis of other measures of between-neighbourhood inequality, the results that (Wheeler, 2008:51-53) state are: as regards OLS’ models, a) the results suggest clear potential endogeneity problems: *“rising income segregation between neighbourhoods may be associated with rising returns to the highly educated residents, who may desire to live in traditional city centers, and so this would create an upward bias in a truly negative association between density and inequality”* next to this, related to the IV estimation, b) there is a not strong association between density and the difference between the neighbourhoods at the 90<sup>th</sup> and 10<sup>th</sup> percentiles of the log income distribution, c) the difference between the 90<sup>th</sup> percentile and the median tends to increase significantly as cities decentralize, d) the difference between the median and the 10<sup>th</sup> percentile appears to decrease as a metro area population spreads out, and a consequence; g) as city populations spread out, there appears to be an increase in the average incomes of neighbourhoods at the top relative to the middle: *“particularly, high-income households may segregate themselves to a larger extent as population spread out. On the other hand, the gap between the average incomes at the middle of the distribution and those at the bottom shrinks, which may reflect greater income mixing among middle- to lower-income households”*.

Finally, in terms of examining the relationship between urban density and income inequality at census tract level, the main findings that (Wheeler, 2008:51) reaches on are: a) in general

<sup>78</sup> The instruments variables that (Wheeler, 2008) has defined are: 1) lagged shares of density within a metropolitan area, and 2) lagged shares of employment in each of the nine industry previously mentioned (see, previous cite). In this sense, Wheeler’s study uses density and each industry share in 1980 to instrument for the change in density between 1990 and 2000.

the results lead to a similar conclusion: the extent of income inequality observed within tracts shows a strong, negative association with population density, whereas between-tract inequality shows little correlation with density, next to this, in detail, b) the OLS results related to the percentile differences suggest that urban decentralization may be associated with smaller between-neighbourhood gaps, not larger, c) the instrument variable estimation is mostly insignificant, although there is some evidence that the gap between the top and middle of the neighbourhood income distribution widens somewhat as population density declines: *“this finding seems to reflect a decrease in the median relative to the 90<sup>th</sup> percentile, which could be the product of greater mixing of medium- and low-income household in suburban neighbourhoods”* and consequently, d) urban decentralization tends to be accompanied by widening income gaps within census tracts.

Hence, the main contributions that the work carried out by (Wheeler, 2008:55) has made to the literature as regards intra- and inter-urban scale are: a) income inequality –defined by the variance of the logarithm household income distribution- does indeed rise significantly as urban density declines; although, a1) this increase is associated with raising inequality within block groups as cities spread farther from their central core and; a2) the extent of income variation between different block groups, by contrast, shows virtually no association with population density: *“there is a little evidence supporting the notion that urban sprawl is systematically associated with greater residential segregation at households by income”*, b) although the results suggest that a strong negative association exists in the variance of a metropolitan area’s household income distribution and its overall population density, the association operates through a within-neighbourhood channel rather than a between-neighbourhood channel: *“that is population of a metropolitan area spreads out, household income inequality increases largely because the extent of income variation among household, within the same block group rises, not because neighbourhoods become more segregated by income”* and finally, when Wheeler’s study carries out a closer inspection, c) the data reveal some evidence that decentralization tends to be accompanied by rising between-neighbourhood income gaps, but this occurs only at the top of the block group income distribution, c1) specifically, the income differential between the block group at the 90<sup>th</sup> percentile of the household income distribution and the block group at the median does increase significantly as metropolitan areas decentralize, c2) however, according to the Wheeler’s study results, the gap between median and the block group at the 10<sup>th</sup> percentile tends to decrease, which leaves measures of the overall spread in the between-neighbourhood income distribution relatively unchanged and, c3) the association between population density and either the average income of the block group at the 90<sup>th</sup> percentile or that of the block group at the 10<sup>th</sup> percentile appears to be little, the same results as census tracts is used as spatial scale of analysis, instead of block groups.

Next to Wheeler’s studies, (Glaeser et al., 2008) discuss about the a) determinants that explain the centralization of the poor population in U.S. cities, b) the empirical evidence on the connection between the location of the poor citizens and proximity to public transportation through considering this connection across cities and within cities and, c) discusses about the ability and implications of changes in transportation technology to explain the changing locational patterns of rich and poor. Briefly, as regards the former question, Glaeser’s study reaches on the results that public transportation is between 2 and 3 times more important than the income elasticity of demand for land in explaining the central location of the poor. Next to this, as regards the latter research question, (Glaeser et al., 2008) point out that the poor are likely to live in cities with more public transportation at the time that they are less centralized when the suburb-central city gap in public transit is less in terms of across cities’ evidence

and related to the within cities analysis, proximity to public transportation does well at predicting the location the poor. Lastly, as regards the last question, Glaeser's study states that in areas where only one mode is used, the rich should live close to the city center; location patterns should change when public transit infrastructure changes the location patterns of the rich and; cities with decentralized employment, poverty should be less decentralized.

Hence, to test empirically its former research question (Glaeser et al., 2008:9) define the two regression models in which the dependent variables are a1) the logarithm of lot size for people who live in single detached dwelling, a2) the logarithm of the unit age and<sup>79</sup>, b) the travel time to work in minutes as regards walking, car, bus and subway means of transport<sup>80</sup>, considering explanatory variables related to a) household income, b) demographic controls and, c) miles to work through using data of American Housing Survey (AHS) in 2003 and National Household Transportation Survey (NHTS) in 2001 respectively. Next to this, Glaeser's study estimates both models by using OLS (ordinary least squares) and IV techniques in which income is instrumented with education. The main results that (Glaeser et al., 2008) reach on are: a) the estimated income elasticity of demand for housing is 0,08 and when is controlled for age, race and household size, the coefficient remains at 0,08, b) the estimated coefficient rises to 0,26 when is used education as a instrument for income, however in this case, it has no impact on housing consumption, c) the estimated coefficient is larger: 0,34 and 0,55 respectively when is constructed the lot size of household for apartment residents and is controlled for other demographic characteristics, d) a statistically and negatively association between income elasticity and demand for new housing: after regressing the logarithm of the age of the home on household income, the elasticities values are -0,05 and -0,23 for the OLS and IV models correspondingly, e) commuters who walk to work take 10,2 minutes per mile, f) car travel takes about 1,6 minutes per mile and a fixed time cost of driving of 5,6 minutes, g) a 22,2 minute fixed cost associated with bus travel and an 18,4 minute fixed cost associated with subway travel what represents that, h) public transportation explains almost three-quarters of the sorting of the poor into the center and demand for land explains one-quarter on average.

As regards, the second research question, (Glaeser et al., 2008:14) estimate two different sets of regression models to present the evidence on the connection between poverty and public transportation. In the first set of regressions, Glaeser's study defines two distinct samples through using tract level data in 2000: a) sixteen U.S. cities<sup>81</sup> and, b) the outer of New York Cities (non-Manhattan) in which the dependent variable in both sample is the logarithm of the tract median household income and, the independent ones are related to a) different band ring distances to the CBD and, b) different band rings distance to rail transit line<sup>82</sup> respectively. In

<sup>79</sup> The first regression models that (Glaeser et al., 2008:9) estimate are: 1)  $\log(\text{Lot Size}) = \alpha + \beta * \log(\text{income}) + \text{other controls} + \varepsilon$  and, 2)  $\log(\text{land per household}) = 0,48 * \log(\text{median income}) + \text{Other controls}$ . The controls included are: a) income, b) metropolitan area fixed effects, c) age, race and household size, and finally, d) householders' age, marital status, race, size of household, and number of children.

<sup>80</sup> The second regression model that (Glaeser et al., 2008:9) define is the following one:  $\text{Time to work} = \alpha + \beta * (\text{distance to work}) + \varepsilon$ , where is only include those commuters that live within 10 miles of their workplace next to metropolitan fixed effects.

<sup>81</sup> The sixteen U.S. cities that Glaeser's study considers are: Atlanta, Baltimore, Boston, Buffalo, Chicago, Dallas, Denver, Los Angeles, Miami, Portland, Sacramento, San Diego, San Francisco, San Jose, St. Louis and Washington D.C.

<sup>82</sup> The independent variables used in the first sample are: 1) Distance from CBD, less than 3 miles, 2) Distance from CBD, between 3 and 10 miles and, 3) Distance from CBD, more than 10 miles. Next to this, the explanatory variables used by Glaeser's study in the second sample are: 1) the three previous ones, 2) Distance to Rail Transit Line, less than 2 miles, 3) Distance to Rail Transit Line, more than 2 miles, 3) Miles to closest Rail Transit Line and, 4) Miles to closest Rail Transit Line-squared.

the second set of regressions, Glaeser's study determines a regression model<sup>83</sup> for the aforementioned sixteen city sample between the period 1980 and 2000 in which the dependent variable is poverty rate and the explanatory variables are related to a) distance to the CBD, b) a set of fixed effects (metropolitan area, tract level and year) and, c) a set of dummy variables<sup>84</sup>. The findings that (Glaeser et al., 2008:15) have revealed are: a) the coefficient on distance is 0,099 within three miles and 0,062 for tracts between three and ten miles of the city center and, b) public transportation usage appears to strongly predict poverty and to explain a substantial amount of the connection between proximity and poverty: the coefficient on distance is 0,0477 between 3 and 10 miles and 0,0439 within more than 10 miles in New York City and, c) a census tract experiences a 0,004 percentage point increase in poverty relative to tracts which has not experimented an increment of accessibility to rail transit in the same metropolitan area that are equidistant to the CBD: *“while the results are modest, they continue to suggest the positive impact of access to public transportation on the location of the poor”*.

Finally, as regards the implications and changes in transport technology to explain the changing of locational patterns, (Glaeser et al., 2008:16) estimate the following three regressions models as regards: a) car zones<sup>85</sup>, b) public transportation and the rich<sup>86</sup> and, c) employment decentralization<sup>87</sup>. The results that (Glaeser et al., 2008:17-21) reach on are: a) a significant negative relationship between distance from CBD and income in car zones, in which the estimated coefficient is -0,0017 within 10 miles of the CBD and -0,0219 as regards more than 10 miles from CBD: *“in an area where only one mode of transportation is being used, richer people appear to live closer the city center. This suggests that the existence of*

<sup>83</sup> The regression model that (Glaeser et al., 2008:16) estimates is the following one:  $Poverty\ rate = \alpha + \beta * Proximity\ to\ Transit + \varepsilon$

<sup>84</sup> The explanatory variables that Glaeser's study considers are: 1) tract within 1 mile of a Rail Transit Line, 2) Fixed effects, 3) Year fixed effects, 4) Distance to CBD, 5) Distance to CBD\*Year dummies, 6) Metropolitan area dummy\*Year dummy, 7) Metropolitan area\*distance to CBD and finally, 8) Metropolitan area\*Year dummy\*Distance to CBD

<sup>85</sup> Glaeser's study defines in this case as a dependent variable the logarithm of a census tract's median household income in 2000. Next to this the independent variables that its study constructs are: 1) within 3 miles of CBD, 2) more than 3 miles from CBD, 3) within 3 miles of CBD\*Subway city (which is 1 if it is the tract's metropolitan area is Boston, Chicago, New York or Philadelphia), 4) more than 3 miles of CBD\*Subway city, 5) within 10 miles of the CBD, 6) more than 10 miles from CBD and finally 7) metropolitan area fixed effects. Moreover, this first type of regression models that Glaeser's study defines, takes the form of three different specifications: 1) logarithm of income at car zone, which is defined as the set of census tracts located between 5 and 15 miles from the CBD in metropolitan areas in which the highest public transit use in that mileage range is less or equal to 2,5%, 2) all census tracts and, 3) all census tracts and percent using public transit.

<sup>86</sup> In this case, (Glaeser et al., 2008:19) define two sets of regression models at the time that for each set of models the sample is classified into a) all, b) old cities and, c) new cities. In accordance with Glaeser's study, the old cities are: Boston, Chicago, New York City and Philadelphia; while the new ones are: Atlanta, Houston, Los Angeles and Phoenix. Next to this, the dependent variable for the former set of models is the poverty rate in 2000; while for the latter one is the logarithm of household median income in 2000. Finally, the independent variables that Glaeser's study considers are: 1) Distance from CBD, less than 3 miles, 2) Distance from CBD, between 3 and 10 miles, 3) Distance from CBD, more than 10 miles and finally 4) a set of metropolitan area fixed effects.

<sup>87</sup> The last regression models that (Glaeser et al., 2008:20) consider is based on four different specifications. The independent variables for all 4 specifications are: 1) Distance from CBD, 2) MSA (metropolitan standard area) employment centralization (which is the share of metropolitan area total jobs that are within five miles of the CBD)\*Distance from CBD and, 3) a set of metropolitan area fixed effects. Next to this, in the first specification model, the dependent variable is the commute time (minutes) in 2000 at census tract level and; in the second one is the logarithm of income at census tract level in 2000. Then in the third one, the dependent variable is the commute time (minutes) including all people sample in the 2001 National Household Transportation Survey (NHTS); and finally, in the last specification, the dependent variable is the commute distance (mile) including also all people sample in 2001 as regards the NHTS data.

*multiple modes of transportation is crucial for understanding why poor live in cities*”, b) in older cities, income generally falls with distance from the CBD for the first three miles, and then rises, c) while in newer cities, income rises monotonically with distance from the CBD, d) the correlation between the logarithm of income and public transportation use at the census tract level in the new cities within three miles of the CBD is -0,509, e) however, in the old cities there is a positive connection between income and public transportation on the basis of 0,259 within three miles of the CBD, f) commute time declines by -0,59 minutes per extra mile of distance from the CBD in a metropolitana area with zero percent of its total employment within five mile of the CBD, g) in a metropolitan area with complete job centralization an extra mile of commute distance increases the average one way commute time by roughly 2 minutes, h) the estimated negative and statistically significant coefficient of employment centralization and distance from CBD (-0,0982) indicates that richer people live further the city center when employment is decentralized, and finally, i) for a commuter who works in a metropolitan area with a high level of job centralization, an extra mile of distance from the CBD entails an increment of the distance to commute by 0,75 miles; while in decentralized cities, commute times rise more slowly with distance from the city center.

Consequently, the main contribution of the work carried out by (Glaeser et al., 2008:23) is that transportation-mode choice plays a key role in explaining income sorting and consequently the ability of different transportation modes could explain the urban concentration of poverty in central locations of cities. Glaeser’s study points out that from this point of view this may be explained through the desire of eliminating transport costs for goods, people and ideas and as a result, in this sense transport technologies could determine the structure of cities. Next to this, Glaeser’s study also contributes to the literature, by explaining the different impact of the rise of public transport and technological change of transportation on U.S. cities and European cities. In this sense, its study relates the dynamics of rich people to stay within central cities, instead of leaving from them because of the improvements in transportation technology (the case of U.S. cities), to the presence of central urban amenities. This issue apart from being studied in-depth by the aforementioned study of (Brueckner et al., 1997) is also examined by (Glaeser, 2000).

Therefore, in this last work, (Glaeser,2000:107) points out that “*cities continue to be attractive to the rich and that the demand for agglomeration is not clearly decreasing*”. To do so, (Glaeser, 2000:135-136) discusses about the consumer’s city concept and regards the relationship between per capita income, accessibility/proximity to the agglomeration economies that arise from CBD and the presence of urban amenities state: a) “*the relationship between the distance from the central business district (CBD) and the logarithm of median income for four traditional metropolitan areas by census tract within 3 miles of the CBD, is strongly negative. Richer people live closer to the CBD. This relationship levels off and then disappears farther away from the CBD*” and, b) “*the relationship between the change in income and distance to the CBD for the same subsample of U.S. tracts. There is a significant positive relationship between income growth and proximity to the CBD*” as a consequence of that wealthy people choosing because of the attractions of urban life to move into gentrifying downtown areas that where previously much poorer as well as the fact that central cities have experimented the resurgence of the financial industry and its strong appeal as a center for consumption. Therefore, the explanations that (Glaeser, 2000:136) gives are: a) “*if the productive edge in cities weakens, then it may be that this role of the city as a center for consumption may be the driving force for urban growth in the future*” and, b) “*these cities are not attracting the rich because of cheaper manufacturing goods. These are little differences in these prices over space, and generally the large land costs involved in retail*

*trade in cities mean that traded goods are usually more expensive in cities. The amenities of urban life do often come from less expensive and more available services in cities. There already exists a rich literature of the role of urban markets in increasing the division of labor and the range of available products. These standard market forces are one reason why cities are appealing as centers for leisure activities” and “public amenities such as museums and theaters are another classic market-related reason for the popularity of some cities”.*

Another meaningful work in the literature, as regards urban inequality is the research conducted by (Glaeser et al., 2009) in which determines the causes and the consequences of urban inequality between U.S. metropolitan areas (so, through considering a inter-urban scale) between 1980 and 2000. To do so, on the one hand, Glaeser’s study builds a theoretical and an empirical framework in order to explain the causes of urban inequality in 1980 and in 2000 by focusing on analyzing the role that heterogeneous human capital plays in explaining the differences in inequality across space and the causes of that heterogeneous human capital<sup>88</sup>. On the other hand, Glaeser’s study investigates the consequences of urban inequality on the basis of analyzing the determinants that explain the changes of 1) population growth between 1980 and 2000, 2) income growth between 1980 and 2000 and finally, 3) murder rate across metropolitan areas by considering characteristics of the metropolitan areas related to a) size, b) initial conditions, c) human capital and, d) amenities.

In this sense, (Glaeser et al., 2009:628) conducts the former analysis by estimating a set of 7 different regression models<sup>89</sup> in which the dependent variable is the Gini coefficient in 1980 and 2000, and the results that its study reaches on are: a) human capital variables are extremely significant and they increase the amount of variance explained, ( $R^2$ ) from 15 percent to 49 percent, so more than one-third of the heterogeneity in income inequality across metropolitan areas can be explained by, share of adults with college degree and, the share of adults who are high school graduates, b) the share of college graduates increases by 10

<sup>88</sup> The approach that (Glaeser et al., 2009:626) define is based on assuming that earnings reflect the interaction of human capital and the returns to human capital in this way: 1) “if human capital is reduced to being a scalar  $h$ , then the wage associated with each value of  $h$  is  $w_i(h)$  where ( $i$ ) represents each place”, 2) “if the density of population in each area with human capital level ( $h$ ) is  $g_i(h)$ , then the average earnings in a locality is equal to  $\int_h w_i(h)g_i(h)dh$ ”, 3) “thus, the density income will be  $g_i(w_i^{-1}(y))$  where  $G_i(w_i^{-1}(y))$  denotes the cumulative distribution of income”, 4) “if  $w_i(h) = \alpha_i + \beta_i h$ , then the variance of wages within a place is equal to  $\beta_i^2 Var_i(h)$ , where  $Var_i(h)$  is the variance of ( $h$ ) within place ( $i$ )”, 5) “the Gini coefficient is  $1 - \frac{1}{\hat{y}_i} \int_y (1 - G_i(w_i^{-1}(y)))^2 dy$ ”, and finally, 6) “if ( $h$ ) is distributed uniformly on the interval  $[\hat{h}_i - 0,5\sigma_i, +\hat{h}_i - 0,5\sigma_i]$  then the Gini coefficient is  $1 - \frac{(\beta_i)^3 \sigma_i}{3(\alpha_i + \beta_i \hat{h}_i)}$ , which is a function of both the distribution of skills and the returns to skill”.

<sup>89</sup> This set of regression models that Glaeser’s defines are: 1) the dependent variable is the Gini coefficient in 1980 and the explanatory determinants are related to population and median family income in 1980, 2) the dependent variable is the Gini coefficient in 2000 and the independent variables are the population and the median family income also in 2000, 3) the dependent variable is the Gini coefficient in 2000 and the explanatory variables are population, median family income, the percentage of population above 25 years with a bachelor degree and the percentage of population above 25 years with a high school degree, all constructed in 2000, next to these regression models, Glaeser’s study addresses the problem of endogeneity that arises from the estimation by defining these following models, 4) the dependent variable is the Gini coefficient in 2000 and the determinants are defined as population and median income family in 2000 next to percentage of population above 25 years with a bachelor degree in 1940 and percentage of population above 25 years with a high-school degree in 1940, 5) the same as previously but by using percentage of population enrolled in college in 1850 and, percentage of population enrolled in a high-school in 1850 as a variables to address endogeneity, 6) the same as model 5, but by including two more variables, the rate of illiteracy in 1850 and the percentage of enslaved population in 1850 and finally, 7) the dependent variable is the Gini coefficient in 2000, and the dependent variables are population in 2000, median family income in 2000 and, share of workers in manufacturing in 1950.

percent, the Gini coefficient in 2000 rises by 0,031, c) as the share of high school graduates increases by 10 percent the Gini coefficient drops by 0,018; then, when is controlled for the possibility that the inequality of human capital within an area is itself an endogenous response to changes in the returns to skill, d) as regards using share of population with high school and college degrees going back to 1940, human capital levels in 1940 are strongly correlated with inequality in 2000; although the overall  $R^2$  declines now to 35 percent, these two instruments variables incrementally explain more than 15 percent of the variation in the Gini coefficient, e) when is used the share of population enrolled in college and in high school in 1850, the former is a solid predictor of income inequality in 2000 and the latter also continue to negatively predict Gini coefficient in 2000, f) when is added the share of the population that is illiterate in 1850 and the share of population that was enslaved in 1850, then both illiteracy and slavery in 1850, help predict inequality today and adding these variables increases the  $R^2$  of the regression to 26 percent, an additional 6 percent.

Next to this, related to the latter analysis, (Glaeser et al., 2009:640-642) estimate the aforementioned three different regression models<sup>90</sup> and, the results that its study reaches on are: a) places with more inequality have been gaining population without controlling other factors and, b) places with more inequality is statistically negative associated with population growth, when is controlled for city-level population, human capital and amenities, c) human capital and amenities are able to predict population growth between 1980 and 2000, d) inequality has a significant negative impact on income growth but it is not statistically significant when is not included a human capital distribution effect: *“these results do suggest that income inequality is only negatively correlated with area growth once we control for skills. Increases in the skill distribution that make a place more unequal by increasing the share of highly educated citizens are associated with increased, not decreased growth”*, e) the negatively and statistically association between initial conditions of median family income and human capital with the income growth between 1980 and 2000, f) a strong positive relationship between income inequality and murder rates across metropolitan areas: *“there is a 35 percent correlation between homicide rates and the Gini coefficient across metropolitan areas”* and finally, g) this relationship is still positive and strongly statistically significant after including the other controls as regards city-level, human capital and amenities.

Consequently, the main contributions that (Glaeser et al., 2009:645) point out are: a) *“the causes of metropolitan are income inequality can be explained well by both differences in the skill distribution and differences in the returns to skill at the time that these differences in the returns to skill appear to be more important in explaining the variation in the Gini coefficient across American metropolitan areas”* and, b) *“more unequal places have higher murder rates, and people say that they are less happy and, though the correlation between area-level inequality and population growth is positive, more unequal places growth more slowly once we control for the distribution in an area”*.

Finally, the study carried out by (Lee et al. 2013) investigates the intra-metropolitan disparities within 9 PMSAs (primary metropolitan statistical areas) in the state of New Jersey by using longitudinal data between 1970 and 2009 on the basis of focusing on inter-jurisdictional inequality and its determinants across 566 municipalities that define these 9

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<sup>90</sup> The explanatory variables that Glaeser’s study defines in order to determine the causes of a) population growth, 1980-2000, b) income growth 1980-2000 and, c) murder rate per 100.000 are the following: 1) Gini coefficient in 1980 for each metropolitan area, 2) population in 1980, 3) median family income in 1980, 4) percentage of population above 25 years with a bachelor degree in 1980, 5) percentage of population above 25 years with a high school degree and, 6) mean January temperatures in 1994.



mentioned PMSAs. In this sense, Lee's study considers the following four main hypotheses or research questions to be tested: a) metropolitan economic growth is associated with intra-metropolitan disparity, so what is the source of intra-metropolitan disparity on the basis of analyzing its inter- and intra-jurisdictional disparity, b) intra-metropolitan disparity emerges from inter-jurisdictional disparities because economic growth in metropolitan areas is unevenly distributed across local municipalities, c) inter-jurisdictional disparity within a metropolitan area arises from the disproportionate distribution of population by income, race, and education and lastly, d) housing market constraints, local taxes, and public expenditures play significant roles in inter-jurisdictional economic disparity, since local municipalities vary in their capacities to provide public goods and services.

To do so, (Lee et al., 2013) estimates two different types of regression models in which the independent variables are referring with a) demographic characteristics, b) socioeconomic factors, c) local taxes, d) public expenditures and, e) housing market constraints<sup>91</sup>. Thus, the former addresses the relationship between metropolitan growth and inequality using longitudinal data between 1970 and 2009, while the latter examines the inter-jurisdictional inequality and its determinants factors. Related to the first regression analysis, Lee's study divide its empirical framework in two steps: 1) by estimating a regression model by using random-effect GLS estimator due to unobserved heterogeneity across PMSAs in which the dependent variable is Theil income inequality index and, the determinants are related to demographic and socioeconomic characteristics<sup>92</sup> next to, 2) by specifying a path regression

<sup>91</sup> The explanatory variables that (Lee et al., 2013:153) define are: 1) POP, which is total population, 2) POP8009R which is the population change rate between 1980 and 2009, 3) POPD which is population density measured as person per square mile, 4) POP80D which is the population density in 1980 and calculated as previously, 5) BLK which is proportion of blacks, measured as the ratio between black population and total population, 6) BLK8009 which is the change in the proportion of the black population between 1980 and 2009, 7) HISP which is the proportion of Hispanics measured as the ratio between Hispanic population and total population, 8) HISP8009 which is the change in the proportion of the Hispanic population from 1980 to 2009, 9) EDU which is the proportion of college graduates, calculated as the persons above 25 years old with a college or graduated degree divided by the total population above 25 years, 10) EDU09 is the education measured as previously in 2009, 11) EDU8009 which is the change in proportion of college graduates between 1980 and 2009, 12) POV which is the poverty rate measured as the ratio between total persons below the poverty level and the total population with poverty status determined, 13) POV8000 which is the change in the proportion of poverty between 1980 and 2000, 14) DISSIM which is the dissimilarity index for racial segregation among white, black, and Hispanics at the municipality level in PMSAs, measured as follows:  $DI = \sum_{i=1}^n \left[ \frac{t_i |x_i - X|}{27X(1-X)} \right]$ , where ranges from 0 to 1 and in which 0 indicates no segregation and a value of 1 implies complete segregation, 15) EDU\_DISP which is the disparity index for college graduated population at the municipality level in PMSAs, measured as the standard deviation of the proportion of human capital (college graduates) for municipalities in each PSMA and in which a high standard deviation indicates a disproportional distribution of human capital across municipalities in a PMSA, 16) MTAX which is the municipality tax rate, 17) MTAX80 which is the municipal tax rate in 1980, 18) MTAX8005 which is the change in the tax rate between 1980 and 2005, 19) BUDPC which is the governmental expenditures per capita, measured as the ratio between municipal budget and capita, 20) BUDPC8003R which is the change rate in the municipal budget per capita from 1980 to 2003, 21) AHV which is the average residential value measured in dollars, 22) AHV9005R which is the change rate of the average housing value between 1990 and 2005, 23) BLT49P which is the proportion of housing built before 1949, 24) BLT5069P which is the proportion of housing built between 1950 and 1969, 25) BLT7089P which is the proportion of housing built between 1970 and 1989, 26) BLT9000P which is the proportion of housing built between 1990 and 2000 and finally, 27) YEAR which are time dummy variables in the following years: 1970, 1980, 1990, 2000 and 2009.

<sup>92</sup> Hence, in the first step of its empirical framework, (Lee et al., 2013:153) estimate the following regression model:  $Y_{it} = \beta_0 + \beta X_{it} + \alpha_i + \varepsilon_{it}$ , where  $i$ = PMSAs,  $t$ = time (1970, 1980, 1990, 2000, and 2009),  $(Y_{it})$  is the Theil income inequality index in  $(i)$  PMSA at  $(t)$  time,  $(X_{it})$  are demographic and socioeconomic variables in  $(i)$  PMSA and  $(t)$  time (PCI, BLK, HISP, EDU, DISSIM, EDU-DISP and, the dummy variables in 1970, 1980, 2000 and 2009),  $(\alpha_i)$  is the unobserved heterogeneity across PMSAs and  $(\varepsilon_{it})$  is the error term.

model for the Theil income inequality in PMSAs based on theoretical relationships among racial segregation and the disproportional distribution of human capital at the municipality level in PMSAs which at the time that is also considered their indirectly effect on the per capita income level across municipalities<sup>93</sup>. Then, in terms of the second analysis on the basis of analyzing inter-jurisdictional inequality, (Lee et al., 2013) estimate a set of regression models through using OLS (ordinary least squares), SLM (spatial lag model) and SEM (spatial error model) techniques depending on the case (if there is or not spatial dependence), in which the dependent variables are: a) per capita income 2009, b) per capita income change rate between 1980 and 2009, c) per capita property tax base 2005 and, d) per capita property tax base change between 1980 and 2005 and, the independent determinants are static and dynamic variables for demographic and socioeconomic conditions, housing market constraints, local taxes, and public expenditures<sup>94</sup>.

Hence, the results as regards the former analysis that (Lee et al., 2013) reach on are: a) per capita income of the metropolitan has a strong positive influence on the Theil inequality (with values of elasticities that range from 3,3E-06 to 1,5E-06), b) the dissimilarity index for racial segregation and the disparity index for college graduates are statistically associated with the inter-jurisdictional inequality (with values elasticities that range from 0,107 to 0,140 as regards racial segregation and a constant value of 0,002 related to the college graduates) and, consequently c) an increase in intra-metropolitan inequality stems not only from income growth in a metropolitan region, but also from the inter-jurisdictional distribution of poor minorities and the human capital advantage that a college education. Next to these results, the findings related to the path regression analysis that (Lee et al., 2013:155) obtain are: a) regional income level (PCI) has a direct impact on regional income inequality (Theil index), b) racial segregation and the disparity of college graduates across municipalities have direct and indirect impacts on the regional income inequality index: b1) human capital has a direct impact of 0,361 and indirect impact of 0,428 (0,795\*0,538) via regional per capita income on the regional income inequality index next to a strong direct impact on the regional income level (0,795) and, b2) racial segregation index is directly positively and negatively associated with regional income inequality index (0,185) and with per capita income (-0,351) respectively at the time that it exerts an indirectly and negatively influence (-0,351\*0,538) on the regional income inequality index, and as a result, c) the path regression analysis reveals theoretically causal relationships and interaction among economic growth levels, minority population, human capital disparity, and economic inequality.

Then, in terms of the latter regression analysis, (Lee et al., 2013:156) point out that: on the one hand, as regards per capita income in 2009 and its subsequent growth between 1980 and

<sup>93</sup> The specification of the path regression model that (Lee et al., 2013:153) define is: firstly 1)  $Y_{it}(\text{Theil Index}_{it}) = \beta_0 + \beta_1 * PCI_{it} + \beta_2 * DISSIM_{it} + \beta_3 * EDU\_DISP_{it} + \epsilon_{it}$  and secondly, 2)  $Y_{it}(PCI_{it}) = \beta_0 + \beta_1 * DISSIM_{it} + \beta_2 * EDU\_DISP_{it} + \epsilon_{it}$ , where i=PMSAs, t=time (1970, 1980, 1990, 2000 and 2009), Theil Index<sub>it</sub>= Theil income inequality index in (i) PMSA at (t) time, PCI<sub>it</sub>=per capita income in (i) PMSA at (t) time, DISSIM<sub>it</sub>= dissimilarity index for racial segregation in (i) PMSA at (t) time, EDU\_DISP<sub>it</sub>=disparity index for college graduates in (i) PMSA at (t) and finally, ( $\epsilon_{it}$ ) which is the error term.

<sup>94</sup> In this sense, (Lee et al., 2013) estimate the regression models as regards per capita income in 2009 and per capita income growth between 1980 and 2009 by using a spatial-error model next to estimate the models related to per capita property tax in 2005 and per capita property tax growth between 1980 and 2006 through using spatial-lag model and ordinary least squares techniques respectively. In addition, the independent variables that Lee's study includes in all of these regression models are: 1) PCI80/PCPT80LN, 2) POP80D, 3) BLK80, 4) HISP80, 5) EDU80, 6) POV80, 7) MTAX 80, 8) BUDPC80, 9) AHV90, 10) POP8009R, 11) BLK8009, 12) HISP8009, 13) EDU8009, 14) POV8000, 15) MTAX8005, 16) BUDPC8003R, 17) AHV9005R, 18) BLT49P, 19) BLT7089P and finally, 20) BLT9000P.

2009, a) initial variables in 1980 on the basis of per capita income, college graduates, and average housing value are strong predictors of per capita income in 2009 and its change from 1980 and 2009, b) per capita income and its growth are negatively associated with the growth of the population, the growth of the Hispanic population, and the growth of poverty, c) per capita income and its growth are positively associated with the growth of the college graduate population, and the growth of the government budget per capita, and c) municipalities with relatively recent housing stock and higher average housing value exhibit higher levels of per capita income and per capita income growth; then, on the other hand, related to per capita property tax base in 2005 and its growth, d) both models indicate that the per capita property tax base and its growth have strong positive relationships with the average housing value and its change, e) governmental expenditure and its change also have strong positive relationship with the per capita property tax base and its change, f) an increase in the tax rate has a strong negative impact on the per capita property tax base and its change: *“local municipalities in suburban areas with a lower level of taxes have an advantage in attracting jobs and middle- and upper-income households over urban municipalities. Since the property tax base is the most critical source of funding for public services and economic development, low-income communities face the dilemma of either raising taxes or reducing public services and are thus at a disadvantage compared to prosperous suburban communities”*, g) the minority population level and its change do not exert a statistically significant influence on a municipality’s per capita property tax base at the time that the increase in human capital by means of college graduates has a consistent positive impact on the per capita property tax in 2005 and its subsequent growth between 1980 and 2005.

Consequently, the main contributions of the study carried out by (Lee et al., 2013:157) are: a) regional income growth is positively associated with income inequality across municipalities which is not consistent with the previous explained study of (Wheeler, 2004), b) its study confirms that the disproportionate distribution of minority and human capital, represented by college graduates, is statistically significant factors for explaining inter-jurisdictional income disparity, c) the levels of per capita income and their growth within municipalities depend on changes in low-income minority population, college educated human capital and public investment and in particular, on the human capital which has been revealed as the most robust predictor for per capita income growth of a municipality, which is consistent with the findings of the aforementioned study of (Glaeser et al., 2009), d) the increase in governmental expenditure per capita is positively associated with municipality income level, indicating inter-jurisdictional economic disparities and finally, e) local housing market constraints, such as housing stock and housing value, also play a statistically significant role in widening inter-jurisdictional urban inequality.

#### **2.4. Evidence on the effect of agglomeration economies and other determinants**

In this Section 2.4, we attempt to synthesize the effect (dynamic and static) of spatial and non-spatial characteristics of cities in wages/incomes. Hence, the following (Tables 1a-1g) present the results as regards the relationship between urbanization externalities, localization externalities, Jacobs externalities, local competition externalities, firm size, human capital externalities, demographic variables, and amenities, with wages that the 42 aforementioned studies, explained in-depth in the previous Section 2.2 and Section 2.3 have found.

The comparison analysis shows that in general, the urban standard theory is satisfied. Referring with urbanization economies by means of employment density (or total

employment) and population density (or total population), most of the analyzed studies reveal a positively statistically association between urbanization economies and wages/incomes at the time that it also predict its growth (dynamic externalities). This relationship is presented by the studies of (Lewis and Prescott, 1974; Carlino and Voith, 1992; Glaeser et al., 1992; Glaeser, 2000; Graham, 2000; Wheaton and Lewis, 2002; Fingleton, 2003; Glaeser and Kahn, 2004; Fingleton, 2006; Graham and Kim, 2008 –in 9 industries-; Combes et al., 2008; Glaeser et al., 2008 –in the cases of subway and old cities-; Melo and Graham, 2009 –in 2 out of 12 industries-; Combes et al., 2010 and; Graham et al., 2010 –in 7 out of 11 industries) and (Lewis and Prescott, 1974; Sveikauskas, 1975 –in 11 out of 14 industries-; Carlino, 1985; Carlino and Voith, 1992 –by considering the whole economy-; Harris and Ioannides, 2000; Glaeser and Maré, 2001; Glaeser et al., 2001; Wheeler, 2001; Glaeser and Saiz, 2003; Glaeser and Shapiro, 2003 –by considering the whole economy-; Glaeser and Kohlhase, 2004; Kim, 2006; Rice et al., 2006 –below 80 minutes-; Yankow, 2006; Di Addario and Patacchini, 2008 –below 12 km-; Glaeser et al., 2009; Goetz et al., 2010; Glaeser and Resseger, 2010 and; Lee et al., 2013 –as regards per capita property tax base growth-) as regards using employment or population respectively, as a proxy for urbanization economies. However, other few studies have pointed out a negative association (Glaeser et al., 1995; Graham, 2000 –manufacturing wages in 1984-; Wheeler, 2004; Wheeler, 2008 –as regards variance of income for metropolitan areas and changes in within neighbourhood income; Glaeser et al., 2008; Melo and Graham, 2009 –in 1 out of 12 industries-; Glaeser et al., 2012 –as regards counties income growth- and; Lee et al., 2013 –as regards population growth-) or a not statistically significant effect (Sveikauskas, 1975 –in 3 out of 14 industries; Rauch, 1991; Carlino and Voith, 1992 –by considering manufacturing wages-; Graham, 2000 –manufacture wage in 1991; Glaeser and Shapiro, 2003; Fingleton, 2006; Rice et al., 2006 –between 80 and 120 minutes-; Wheeler, 2008 –as regards changes in between neighbourhood income-; Melo and Graham, 2009; Graham et al., 2010 –in 4 out of 11 industries; Glaeser et al., 2012 –related to counties change in median income- and; Lee et al., 2013 –as regards population density-).

Next to this, localization economies, Jacobs economies, local competition externalities and firm size also foster wages in most cases, although most studies in the literature have paid less attention on examining the effects of these agglomeration externalities on wages compared to the aforementioned urbanization economies externalities. In this sense, the studies of (Lewis and Prescott, 1974; Carlino and Voith, 1992 –in 6 out of 8 industries-; Glaeser, 2000; Graham, 2000; Wheeler, 2001; Wheaton and Lewis, 2002; Wheeler, 2004 –as regards per capita income growth-; Combes et al., 2008; Glaeser et al., 2008 –in subway and old cities -; Melo and Graham, 2009 –in 2 out of 12 industries-; Graham et al., 2010 –in 7 out of 11 industries- and; Glaeser et al., 2012) find that localization economies predict wages/income, while the works of (Carlino and Voith, 1992 –in 1 out of 6 industries-; Glaeser and Shapiro, 2003 –by considering the whole economy-; Wheeler, 2004; Wheeler, 2008 and; Glaeser et al., 2008) and (Carlino and Voith, 1992 –in 1 out of 6 industries-; Glaeser et al., 1992, 1995; Glaeser and Saiz, 2003; Glaeser and Shapiro, 2003; Wheeler, 2004; Wheeler, 2008; Melo and Graham, 2009 –in 10 out of 12 industries- and; Graham et al., 2010) reveal a negative association and a not statistically significant influence respectively. In addition, this divergence of results, referring with localization economies effects, also occur as regards Jacobs externalities: while the investigations conducted by (Glaeser et al., 1992 and; Melo and Graham, 2009 –by considering the whole economy-) find a positively statistically association between diversity and wages, other studies reveals a negatively association (Combes et al., 2008; Melo and Graham, 2009 –in 2 out of 12 industries- and; Goetz et al., 2010) or a not statistically significant one (Melo and Graham, 2009 –in 10 out of 14 industries-). The same for local competition externalities and firm size: meanwhile the works

of (Lewis and Prescott, 1974 and; Melo and Graham, 2009 –in the whole economy and in 9 out of 12 industries) state that firm size predict wages, the studies of (Glaeser et al., 1992; Wheaton and Lewis, 2002; Combes et al., 2008 and; Glaeser et al., 2009) and (Melo and Graham, 2009 –in 1 out of 12 industries- and; Glaeser et al., 2012) reveal that local competition and firm size are negatively correlated with wages correspondingly.

Then, this disparity of results is highly disappeared as regards the effects of human capital externalities on wages. In this case, the majority of the aforementioned 42 studies that examine the role of human capital point out a positively statistically relationship. This is the case of the studies carried out by (Sveikauskas, 1975; Rauch, 1991; Carlino and Voith, 1992; Glaeser et al., 1995; Harris and Ionnides, 2000; Graham, 2000; Glaeser and Maré, 2001; Wheeler, 2001; Fingleton, 2003; Glaeser and Saiz, 2003; Glaeser and Shapiro, 2003; Glaeser and Kohlhase, 2004; Moretti, 2004; Wheeler, 2004; Berry and Glaeser, 2005; Shapiro, 2005; Fingleton, 2006; Rice et al., 2006; Wheeler, 2006; Yankow, 2006; Wheeler, 2008; Combes et al., 2008; Di Addario and Patacchini, 2008; Glaeser et al., 2009; Goetz et al., 2010; Glaeser and Resseger, 2010; Glaeser et al., 2012 and; Lee et al., 2013). However, the few exceptions are found in the works of (Wheeler, 2001; Moretti, 2004 and; Yankow, 2006 –as regards square experience-; Di Addario and Patacchini, 2008 –interaction variable between population and education and tenure; Glaeser et al., 2009 –related to high-school effect- and; Glaeser and Resseger, 2010 –related to education between 0 and 11 years-) and (Sveikauskas, 1975 –in 10 out of 14 industries-; Rauch, 1991 –experience at MSA scale-; Glaeser and Shapiro, 2003; Wheeler, 2004 –as regards change 90<sup>th</sup>-10<sup>th</sup> weekly wage differential-; Berry and Glaeser, 2005 –between 1990 and 2000 as regards average wage-; Wheeler, 2006 and; Glaeser et al., 2009; –related to high-school effect- and; Lee et al., 2013 –by considering Theil income inequality-) which reach on a negatively association and a not statistically relationship between human capital and wages respectively.

Finally, as regards non-spatial characteristics, the 42 analyzed studies have pointed out that demographic characteristic of cities (i.e. nonwhite, hispanic, immigrant, married, men, female, age structure -<24 years, >65 years-) and the presence of amenities (i.e. geographical location: north, south; average heating days, average annual precipitation and January temperature) play in most cases, a highly significant role to explain the levels and the growth of wages/incomes in cities. For instance, most of studies stress that men, white and married population predict wages and its growth (Wheeler, 2001; Kim, 2006; Wheeler, 2006 and; Yankow, 2006), while non-white, black and hispanic do not (Glaeser and Maré, 2001; Glaeser and Shapiro, 2003; Moretti, 2004; Yankow, 2006 and; Lee et al., 2013). Similarly to demographics' effect, the research conducted by (Glaeser et al., 1992, 1995; Glaeser and Saiz, 2003; Glaeser and Shapiro, 2003 and; Glaeser et al., 2012) reveals in general that January temperature and average heating days are negatively associated with income and its growth, while northern and southern locations and longitude are able to foster it. In addition, it is worth mentioning that next to these aforementioned spatial and non-spatial characteristics of cities which are the most used by the researchers in order to examine the determinants of wages and its subsequent growth, there are other variables used to a less extent, which have also exert an statistically significant on wages. These are the cases of unemployment rate (Glaeser et al., 1995; Glaeser and Saiz, 2003 and; Wheeler, 2004, 2008), initial conditions of income or income growth (Glaeser et al., 1995; Glaeser and Saiz, 2003; Wheeler, 2004; Berry and Glaeser, 2005; Shapiro, 2005; Glaeser et al., 2009; Glaeser et al., 2012 and; Lee et al., 2013), expenditure per capita, (Glaeser et al., 1995), commuting (Fingleton, 2003, 2006; Glaeser and Kohlhase, 2004; Glaeser et al., 2008 and; Melo and Graham, 2009) governmental expenditures, municipal tax and poverty rate (Lee et al., 2013) among others.

**Table 1a. Evidence on the effect of agglomeration economies and other non-spatial characteristics on wages/incomes**

Author(s)	Main variable to be explained	Urbanization externalities						Localization externalities			Jacobs externalities			Local competition externalities			Firm size			Human Capital externalities			Demographic variables			Amenities		
		Employment density			Population density			(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no
Lewis and Prescott (1974)*	Ratio between annual production worker wages and number of production workers 1963	(+) dist major reginl markt		(+) size				(+) dist major reginl markt							(+)													
*other variables that it considers are: capital/labor ratio (negative and significant)																												
Sveikauskas (1975)	14 Manufacturing wages 1967			(+11) (size)		(+3) (size)												(+4)		(+7) (-3)							(+) East, West, Midwest	
Carlino (1985)*	Manufacture wages 1957-1997			(+) size		(-) congestion																						
*other variables that it considers are: output and labor (positive and significant)																												
Rauch (1991)*	Whole economy, wages 1980					(+) size												(+)	edu exp	(+)	SMS A exp					(+) coast, west, nrth-east/cntrl		
*other variables that it considers are: culture per capita (negative and significant)																												
Carlino and Voith (1992)*	Whole economy, wages 1986	(+) size		(+) size		(-) congestion		(+) manf, constr, FIRE, servc, trade, transp	(-)	mining	(+)	non-agrilt emply								(+)								
	Manufacture wages 1986	(+) size					(+) size, (-) congntn	(+)	non-agrilt emply	(-)	manf									(+)								
*other variables that it considers are: highway density (positive and significant/not significant), government (positv and not signt), real gross state product (negative and signt), time (negatv/positv and not signt/signt) energy shock (negatv/positv and signt/not signt)																												
Glaeser et al., (1992)*	Wage growth 1956-1987	(+) size							(-)	(+)																	(+) south	
*other variables that it considers are: wage in the city-industry (negative and significant)																												
Glaeser et al., (1995)*	City income growth 1960-1990			(-) size				(-) manf										(+)		(+)	nonwhite					(+) south central	(-) nrthest	
*other variables that it considers are: per capita income (negative and significant), per capita expenditure (positive and significant), unemployment rate (negative and significant)																												
Harris and Ioannides (2000)	Median income family 1980-2000			(+), (+) size														(+)	(+)	state FE	MA FE							
Glaeser (2000)	Median income 1990	(+) distCBD						(+) distCBD																				
	Median income 1980-1990	(+) distCBD						(+) distCBD																				
Graham (2000)*	Manufacture wages 1984	(+) size	(-) size square, (-)					(+)												(+)								
	Manufacture wages 1991	(+) size	(-) size sq., (-)					(+)												(+)								
*other variables that it considers are: dummy London (positive and significant), dummt metropolitan counties (positive and not significant), proportion of workers part-time (positive/negative and not significant), dispersion economies (negative/positive and significant)																												

Source: Own Elaboration

**Table 1b. Evidence on the effect of agglomeration economies and other non-spatial characteristics on wages/incomes**

Author(s)	Main variable to be explained	Urbanization externalities						Localization externalities			Jacobs externalities			Local competition externalities			Firm size			Human Capital externalities			Demographic variables			Amenities						
		Employment density			Population density			(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no				
		(+)	(-)	no	(+)	(-)	no																									
Glaeser and Maré (2001)	Hourly wage for individuals 1990				(+)	>5E06,													(+)	exp								(-) nonwhite				
	Metropolitan area income 1980				(+)	size													(+)	edu												
	Metropolitan area income 1990				(+)	size																										
Glaeser et al., (2001)	County income 1988				(+)	size																										
	County income 1998				(+)	size																										
Wheeler (2001)*	Hourly wage of workers 1980				(+)	size				(+) prof, technical, service, craft, operator									(+), exp, (+av MA), avex pMA	(-) exp (sq)	(+) female, race (white), married	(-) feml*race, feml*married, feml*child, disabled										
*other variables that it considers are: in school (negative and significant), female*experience (negative and significant), female*experience (square) (positive and significant)																																
Wheaton and Lewis (2002)	Imputed hourly wage 1990		(+)	occup, industry					(+)	occup, industry																					(-) conct, specilt	
Fingleton (2003)*	Level of wage rates 2000		(+)																												(+), tech kldge	
*other variables that it considers are: spillover nearby areas (positive and significant), ommitted variables (positive and significant)																																
	MSA family income 1970-2000																															(+) (-) drop out
	Average city family income 1970-2000																															(+) (-) drop out
Glaeser and Saiz (2003)*	IPUMS wage (males >21) 1970-2000																															(+), gwth
	Ratio between average wages and accraprices 1970-2000				(+)	size				(-) manf, servcs, (+) trade																(-) averg heating days	(-) average annual precip					
*other variables that it considers are: average income family (negative and significant), unemployment rate (negative and significant), colleges per capita (positive and significant), share of Bachelors*dummy 1990/2000 (positive and significant)																																
	Ratio between average manufacture wages and accraprices 1970-2000				(-)	size				(+) manuf, servc, trade																						(+) (+) avg annual precip, avg heating days
Glaeser and Shapiro (2003)*	Ratio between IPUMS adjusted wages and accraprices 1970-2000				(-)	size				(-) manuf, servc (+) trade																(+) avg annual precip	(+) avg heating days					
	Whole economy, wages 1970-2000				(+)	size				(-) manf, servcs (+) trade																	(-) precip, heatday					(+)
*other variables that it considers are: temperature*share bachelors (negative and significant), average wage receipts per workers (negative and significant), share immigrant*share bachelors (positive and not significant)																																

Source: Own Elaboration

**Table 1c. Evidence on the effect of agglomeration economies and other non-spatial characteristics on wages/incomes**

Author(s)	Main variable to be explained	Urbanization externalities			Localization externalities			Jacobs externalities			Local competition externalities			Firm size			Human Capital externalities			Demographic variables			Amenities			
		Employment density	Population density		(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	
Glaeser and Kahn (2004)	Income per capita 2000	(+)																								
Glaeser and Kohlhase (2004)	Median household income 1989		(+)														(+)	BA, HS								
	Median earnings 2000		(+)														(+)	BA, HS								
*other variables that it considers are: annual delay per person, a proxy for congestion (positive and significant), annual delay per person (square) (negative and significant)																										
Moretti (2004)*	Average wages 1979-1994																(+)	(-) exp (sq)		(-) female, black, hispanic						
	Average wages of education groups 1980-1990																(+)	<HS, HS, sC, >C								
	Average wages of education groups 1980-1990																(+)	<HS, HS, sC, >C								
	Average wages of education groups 1990																(+)	<HS, HS, sC, >C								
*as regards the econometric models of average wages of education groups, Moretti's study uses a IV estimation with 1) age structure 1970 to predict college share 1980-1990 and 2) land-grant college in the city to predict college share in 1980 and in 1990.																										
Wheeler (2004)*	Change 90-10 logarithm weekly wage differential 1970-1990	(-) size growth	(-) size growth				(-) manf, incm modl	(-) manf, pop emp modl										(-) colle ge rate	(+) change foreign rate	(-) change union rate						
	Per capita income growth 1970-1990						(+) manuf										(+)	(-) colle ge rate	CnHS, CsHS, CHS, CsC							
*other variables that it considers are: per capita income growth (negative and significant), unemployment rate (positive/negative and not significant), 10th percentile (negative and significant), 90th percentile (positive and not significant)																										
Berry and Glaeser (2005)*	Per capita income 1970/2000																(+)	70, 00								
	Hourly income for individual 1980-2000																(+)	80, 90, nn								
	Average wage 1970-2000																(+)	70-90	(+)	90-00						
	Per capita income 1970-2000																(+)	70-00								
*other variables that it considers are: initial logarithm wage (negative and significant 70-80, 80-90 and negative and insignificant 90-00) as regards average wage 1970-2000, initial logarithm income (negative and significant 70-00) related to per capita income 1970-2000																										

Source: Own Elaboration





**Table 1e. Evidence on the effect of agglomeration economies and other non-spatial characteristics on wages/incomes**

Author(s)	Main variable to be explained	Urbanization externalities						Localization externalities			Jacobs externalities			Local competition externalities			Firm size			Human Capital externalities			Demographic variables			Amenities		
		Employment density		Population density				(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no
Combes et al., (2008)*	Local wage index 1976-1998	(+), (+) market potntl 2nd stage						(+) 1st stage				(-) 2nd stage			(-) 1st stage				(+) 1st stage			(+) age 1st stage			(+) mountain 2nd stage	(-) lake heritage 2nd stage	(+) sea 2nd stage	
*other variables that it considers are: land area (positive and not significant), Combes' work uses real wage (logarithm) as a dependent variable in the first stage of its empirical framework																												
Di addario and Patacchini (2008)*	Employees hourly wages rates deflated with the consumer price index (CPI) 1995-2002			(+)	size,			(+) size																				
*other variables that it considers are: middle school*population, short degree-3years-*population (positive and not significant), first degree or above*population (negative and significant), secondary school*population (negative and not significant)																												
Glaeser et al., (2008)*	Tract median household income 2000 in 16 U.S. cities			(-) dist CBD <3, 3<10, >10 miles								(-) dist CBD <3, 3<10, >10 miles																
	Tract income 2000		(+) dist CBD <3, >3 miles	(-) dist CBD <3, subway >3 miles city				(+) dist >3 miles		(-) dist CBD <3, subway >3 miles city																		
	Tract household median income 2000 in 8 U.S. cities		(+) dist CBD <3 miles old city	(-) dist CBD <3 miles new city, 3<10 and >10 all				(+) dist CBD <3 miles old city		(-) dist CBD <3 miles new city, 3<10 and >10 all																		
	109 U.S. MSA income 2000*		(-) distCBD							(-) distCBD																		
*other variables that it considers are: MSA employment centralization*distCBD (negative and significant, richer people live further from the CBD when employment is decentralized)																												
Melo and Graham (2009)*	Real hourly wage 2002-2006	(+), (+) market potntl										(-)	(+)					(+)			(+)	age						
	Real hourly wage in 12 2-digit industries 2002-2006	(+2), (+4) mp	(+2)	(-1)	(+5-4), (+7-1) mp			(+2)		(+2) (-8)	(-2)	(+4) (-6)			(+9)	(-1)	(-2)				(+10) age			(+2) age				
*other variables that it considers are: home-to-work distance (positive and significant), fulltime (negative and significant), area (positive and significant)																												
Glaeser et al., (2009)*	258 U.S. MSA income growth 1980-2000			(+) size														(+)		(-) HS						(-) January temperature		
*other variables that it considers are: median family income (negative and significant), gini coefficient of income (negative and significant)																												

Source: Own Elaboration

**Table 1f. Evidence on the effect of agglomeration economies and other non-spatial characteristics on wages/incomes**

Author(s)	Main variable to be explained	Urbanization externalities						Localization externalities			Jacobs externalities			Local competition externalities			Firm size			Human Capital externalities			Demographic variables			Amenities			
		Employment density		Population density				(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	
		(+)	(-)	(+)	(-)	(+)	(-)																						(+)
Glaeser et al., (2009)*	242 U.S. MSA Gini income coefficient 2006				(+)	size													(+)	(-)	HS								
	282 U.S. MSA Gini income coefficient 2000				(+)	size							(-)	manf 1950					(+)	(-)	HS 2000 1940 1850				(+)	pop enslaved 1850		(+)	illiteracy rate 1850
*other variables that it considers are: median family income (positive and significant as regards Gini income 2006, negative and significant as regards Gini income 2000), gini coefficient of income (positive and significant related to Gini income 2006)																													
Combes et al., (2010)	Local wages 1976-1998			(+), (+)	market potntl																								
Graham et al., (2010)	11 wages industry sectors 1996-2004			(+7)	market potntl			(+7)		(+4)																			
Goetz et al., (2010)*	Income per capita by place of residence 2000-2007				(+)														(+)						(+)	northeast, southern		(-)	western
	Earnings per job by place of work 2000-2007				(+)			(-)	urb. includ.										(+)								(-)	(+)	northeast
*other variables that it considers are: initial conditions, land (positive and significant), in-degree (positive and significant), out-degree (negative and significant / negative not significant) and in*-outdegree (positive / negative not significant)																													
Glaeser and Resseger (2010)*	335 U.S. MA per capita income 2000				(+)	size													(+)										
	335 U.S. MA median income family 2000				(+)	size													(+)										
	U.S. individual yearly earnings 2000				(+)	size													(+),	(-)	educ educ 13- 17, >17y ears								
	100 U.S. MA real family income 2000				(+)	size														(+)									
	37 U.S. MSA wages 2000				(+)														(+)										
*other variables that it considers are: population*share of bachelors (positive and significant), population*experience (negative and not significant as regards individual earnings 2000), percentage bachelors*experience (positive and significant/not significant related to individual earnings 2000), population*percentage bachelors*experience (negative and significant as regards individual earnings 2000), capital per worker (positive and significant related to MSA wages 2000)																													
Glaeser et al., (2012)*	U.S. counties income growth 1950-2000				(-)	size			(+)	manuf 1950									(+)							(+)	distLake, longitude, temp, distLake	(-)	Janury temp
	U.S. counties change in median income 1980-2000				(+)	size			(+)	manuf 1950									(-)	avg size						(+)	distLake, longitude, temp	(-)	Janury temp
	U.S. counties (>50.000 pop) change in median income 1980-2000				(+)	size			(+)	manuf 1950									(-)	avg size						(+)	distLake, longitude, temp	(-)	Janury temp
*other variables that it considers are: population*bachelor degree (positive and significant, as regards income growth 1950-2000), initial median income (negative and significant related to income growth 1950-2000 and change in counties median income 1980-2000)																													

Source: Own Elaboration

**Table 1g. Evidence on the effect of agglomeration economies and other non-spatial characteristics on wages/incomes**

Author(s)	Main variable to be explained	Urbanization externalities						Localization externalities			Jacobs externalities			Local competition externalities			Firm size			Human Capital externalities			Demographic variables			Amenities										
		Employment density			Population density			(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no	(+)	(-)	no								
		(+)	(-)	no	(+)	(-)	no																													
	Theil income inequality among municipalities in each PMSA 1970-2009																			(+)	dissim ty. educ	(-)	(+) black, hispanic													
Lee et al., (2013)*	Per capita income across 533 municipalities 2009				(-) 1980, size growth 80-09															(+)	80, edu 80-09		(-) hispanics 80-09	(-) black 80, black 80-09 (+) hispanic 80												
	Per capita income growth across 533 municipalities 1980-2009				(-) size growth 80-09	(-) 1980														(+)	80, edu 80-09		(-) black 80-09, hispanic 80-09	(-) black 80, (+) hispanic 80												
*other variables that it considers are: per capita income (positive and significant), dissimilarity index for racial segregation (positive and significant), per capita income 1980 (positive and significant), poverty rate 1980 (negative and not significant), municipal tax 1980 (positive and significant), governmental expenditures 1980 (positive and not significant), average housing value 1990 (positive and significant), poverty rate 1980-2000 (negative and significant), municipal tax 1980-2005 (positive and not significant), governmental expenditures 1980-2003 (positive and significant), average housing value 1990-2005 (positive and not significant).																																				
	Per capita property tax base 2005				(-) size growth 80-09	(+) 1980														(+)	edu 80-09		(-) black 80, black 80-09, hispanic 80-09 (+) hispanic 80, edu 80													
Lee et al., (2013)*	Per capita property tax base growth 1980-2005				(+) 1980	(-) size growth 80-09														(+)	edu 80-09		(-) black 80, black 80-09, (+) hispanic 80, hispanic 80-09, edu 80													
*other variables that it considers are: per capita income (positive and significant), poverty rate 1980 (negative and significant), municipal tax 1980 (positive and significant), governmental expenditures 1980 (positive and significant), average housing value 1990 (positive and significant), poverty rate 1980-2000 (negative and significant), municipal tax 1980-2005 (negative and not significant), municipal tax 1980-2005 (positive and significant), average housing value 1990-2005 (positive and significant)																																				

Source: Own Elaboration

## 2.5. Addressing endogeneity in the estimation of agglomeration economies

The main problem related to the estimation of agglomeration economies is the endogeneity or reverse causality between productivity or one of its proxies (see Masip, 2012b for an extended theoretical revision of this point) and agglomeration. Most of the empirical research assumes that causality runs from agglomeration to wages. This is consistent with standard urban economic theory. Some studies, however, have allowed agglomeration to be simultaneously determined with productivity (or with one of their proxies, i.e. wages). The rationale is that firms and workers migrate to more productive areas and increase their size and density. The following (Tables 2a-2i) summarize how 27 of the aforementioned studies, explained in-depth in the previous Section 2.2 and Section 2.3, have solved the endogeneity problem of agglomeration economies estimation and wages/incomes as a proxies for labour productivity.

Perhaps the most common method used in the literature is define the explanatory variables in the initial year of the considered time period next to often simultaneously, including fixed effects (i.e. state or metropolitan area fixed effects) and several dummy controls (i.e. occupation, industry and demographic dummies) in the model specification which is mostly estimated through using OLS (ordinary least squares), SLM-LM (spatial lag model), SEM (spatial error model), GLS (generalized least squares) and LSDV (least-squares dummy variable model) methods. These are the cases of (Carlino and Voith, 1992; Glaeser et al., 1992, 1995, 2009, 2012; Harris and Ioannides, 2000; Glaeser and Maré, 2001; Wheaton and Lewis, 2002; Glaeser and Saiz, 2003; Glaeser and Shapiro, 2003; Wheeler, 2004, 2006, 2008; Fingleton, 2003, 2006; Yankow, 2006; Graham and Kim, 2008; Di Addario and Patacchini, 2008; Glaeser et al., 2009; Goetz et al., 2010 and; Lee et al., 2013). Next to this procedure to estimate agglomeration economies, another approach is to instrument current levels of agglomeration using lags on population (Kim, 2006 and; Rice et al., 2006), population density (Wheeler, 2004, 2008, Combes et al., 2008, 2010 and; Melo and Graham, 2009), market potential (Combes et al., 2008, 2010 and; Melo and Graham, 2009) and in a less extent, employment density (Wheeler, 2004), per capita income growth (Wheeler, 2004), share of educated and not educated active population (Rice et al., 2006) and industry employment shares (Wheeler, 2008). The relevant argument here is that the densities we observe today are determined by previous patterns of population concentration which are themselves uncorrelated with contemporaneous levels of wages or incomes. However, these instruments may prove less relevant for more disaggregate work analyzing urbanization at smaller spatial scales at the time that similarly, it is hard to see how such instruments could provide adequate correction for endogeneity associated with localization economies, for instance, for modern services industries which have been decentralizing from their original urban locations since the half of twentieth century. These problems of relevance are also likely to apply to contemporaneous instruments constructed from data on geographical characteristics, land area and geological features such as the studies of (Kim, 2006; Di Addario and Patacchini, 2008 and; Combes et al., 2010) have used respectively. Finally, difference-GMM estimation is used by (Combes et al., 2010 and; Graham et al., 2010). However, considerable differences between IV and OLS estimates are found (see, the last column of Tables 2a-2i, where is presented a ratio of IV to LS agglomeration elasticity estimates), what it leads to the conclusion that the effect of agglomeration estimates from correcting endogeneity bias is still unclear: some studies obtain IV estimates that are smaller than the respective LS ones (Kim, 2006; Rice et al., 2006; Wheeler, 2008; Combes et al., 2008, 2010; Di Addario and Patacchini, 2008 and; Melo and Graham, 2009) while others find the opposite effect (Rice et al., 2006; Wheeler, 2008; Combes et al., 2008, 2010; Di Addario and Patacchini, 2008 and; Melo and Graham, 2009). In addition, some studies conclude that if agglomeration does have an endogenous component, it does not appear to induces a substantial bias in estimates at all.

**Table 2a. Studies addressing endogeneity in the estimation of agglomeration economies**

Author(s)	Main variable to be explained / Industry	Spatial Unit	Agglomeration Indicator	Elasticity or Gradient ( $\beta$ )	Time period	Estimation method	Main Instrument used	Instruments Test		Ratio of estimates ( $\beta_{IV}/\beta_{LS}$ )				
								Relevance	Exogeneity-Validity					
Sveikauskas (1975)	14 Manufacturing wages	U.S. Standard	Population (average)	0,0477*	1967	OLS	no instrument variables	-	-	-				
		Metropolitan Statistical Areas	Population (minimum)	0,0160*							Population (maximum)	0,0855*		
Carlino and Voith (1992)	Whole economy, wages 1986	48 U.S. states	Percent urban	1,713*	1967-1986	OLS / GLS (generalized least squares)# / LSDV (least-squares dummy variable model)	Initial conditions	-	-	-				
			Percent urban square	-1,692*										
			Aggregate employment	1,113*										
			Employees non-agricult	0,006										
			Mining	-0,193										
	Construction	1,963*												
	Manufacturing	0,803*												
	Transportation	2,273*												
	Trade	2,125*												
	FIRE	0,484*												
Services	1,111*													
Manufacture wages 1986	48 U.S. states	Percent urban	-0,230											
		Percent urban square	-0,001											
		Aggregate employment	1,060*											
		Employees non-agricult	0,006*											
		Manufacturing	-0,114*											
Glaeser et al., (1992)	Whole economy, wage growth in city industry	170 U.S. cities	Employment city indsty	0,938*	1956-1987	OLS	initial conditions	-	-	-				
			Localization economies	-0,00023										
			Local competition	-0,0845*										
			Jacobs externalities	-0,161*										
Glaeser et al., (1995)	Whole economy, city income growth	203 U.S. cities	Population	-0,013*	1960-1990	OLS	initial conditions	-	-	-				
			Population	-0,012*										
			Manufacture share	-0,144										
Harris and Ioannides (2000)	Whole economy, median income family	U.S. metropolitan areas (43, 47, 48, 51 and 51 between 1950 and 1990 respectively)	Population density	0,055*/0,767*	1950-1990	Panel estimation + State fixed effects	-	-	Hausman Test	-				
			Population	0,0261*/---										
			Population density	0,012*/0,023*	1950-1990	Panel estimation + MA fixed effects								
			Population	0,0901*/---										
			Population density	0,075*1950 / 0,06*1990	1950, 1960, 1970, 1980, 1990	OLS / OLS + State fixed effects#					-	-	Hausman Test	1,98 / 0,584
			Population	0,004 1950 / 0,0329*1990										
Glaeser and Maré (2001)	Whole economy, hourly wage for individuals	U.S. SMSAs (Standard Metropolitan Statistical Areas)	Dense metro city >500000	0,045*/0,282*	1968-1995 (PSID) / 1989-1993 (NLSY)	OLS + fixed effects	-	-	-	-				
			Ndense metro city <500000	0,026*/0,191*										
Wheaton and Lewis (2002)	Imputed hourly wage	U.S. metropolitan workers >400.000 observations	Occupation specialization	3,36*Els / 3,36*	1990	OLS+ fixed effects (metropolitan area, occupation, industry and demographic dummies)	no instrument variables	-	-	-				
			Occupation concentration	0,59*Els / 0,25*										
			Industry specialization	2,78*Els / 0,41*										
			Industry concentration	1,50*Els / 0,35*										
			Establishment specializtn	-1,47*Els / -0,38*										
Establishment concentrtn	-0,69*Els / -0,19*													

Source: Own Elaboration. Note: \*statistically significant, #reported results

**Table 2b. Studies addressing endogeneity in the estimation of agglomeration economies**

Author(s)	Main variable to be explained / Industry	Spatial Unit	Agglomeration Indicator	Elasticity or Gradient ( $\beta$ )	Time period	Estimation method	Main Instrument used	Instruments Test		Ratio of estimates ( $\beta_{IV}/\beta_{LS}$ )					
								Relevance	Exogeneity-Validity						
Fingleton (2003)	Level of wages rates	408 unitary authority and local authority districts in Great Britain	Spillover nearby areas Employment density	0,001373* 0,016446*	2000	TSLs / IV estimation#	Kennedy (1992), Johnson (1984) methods: instrument variables takes value 1, 0, or -1 according if E is in the top, middle or bottom	F-test	-	-					
Glaeser and Saiz (2003)	MSA family income	918 U.S. MSA (metropolitan statistical)	Averg family income (t-10)	-0,336* / -0,143*	1970-2000	OLS	initial conditions	-	-	-					
	Average city family income	2160 U.S. cities	Averg family income (t-10)	-0,231* / 0,042*											
	Ratio between average wages and accraprices	234 U.S. MA (metropolitan areas)	Population (t-10) Share workers manuf (t-10) Share workers services (t-10) Share workers trade (t-10)	-0,03* -0,029 -1,362 2,063							OLS + fixed effects (decade)				
	Ratio between average manufacture wages and accraprices	135 U.S. MSA (metropolitan statistical areas)	Population (t-10) Share workers manuf (t-10) Share workers services (t-10) Share workers trade (t-10)	-0,018* 0,188 0,203 0,505							OLS + fixed effects (decade)				
Glaeser and Shapiro (2003)	Ratio between IPUMS adjusted wages and accraprices	129 U.S. MSA (metropolitan statistical areas)	Population (t-10) Share workers manuf (t-10) Share workers services (t-10) Share workers trade (t-10)	-0,018* -0,069 -0,08 0,262	1970-2000	initial conditions	-	-	-						
	Whole economy, wages 1970-2000	918 U.S. MSA (metropolitan statistical areas)	Population (t-10) Share workers manuf (t-10) Share workers services (t-10) Share workers trade (t-10) Avg wage per worker (t-10)	0,442* -0,185* -1,267* 0,078 -0,417*						OLS + fixed effects (year and region)					
	Change 90-10 logarithm weekly wage differential	U.S. MSA, 103 in 1970; 220 in 1980 and, 226 in 1990	Population growth	-0,33*						1970-1990	GLS + region effects# (also without region effects)	initial conditions	-	-	-
			Change in manufacture	-0,19											
Wheeler (2004)	Per capita income growth	U.S. MSA, 103 in 1970; 220 in 1980 and, 226 in 1990	Change in manufacture	-0,64*	1970-1990	GLS + region effects# (also without region effects)	initial conditions	-	-	-					
			10th percentile income	-0,23*											
	$\beta$ convergence	U.S. MSA, 103 in 1970; 220 in 1980 and, 226 in 1990	90th percentile income	0,02	1970-1990	TSLs + regions effects# (also without region effects)	Logarithm initial population density	-	-	-					
			Manufacture rate	0,22*											
	Change 90-10 logarithm weekly wage differential	U.S. MSA, 103 in 1970; 220 in 1980 and, 226 in 1990	Overall 90-10 differential	-0,4*	1970-1990	TSLs + regions effects# (also without region effects)	Logarithm initial employment density	-	-	-					
			Overall 90th percentile	0,03											
Overall 10th percentile			-0,53*												
Population growth			-0,49*												
Change 90-10 logarithm weekly wage differential	U.S. MSA, 103 in 1970; 220 in 1980 and, 226 in 1990	Change in manufacture	-0,04	1970-1990	TSLs + regions effects# (also without region effects)	Logarithm initial per capita income growth	-	-	-						
		Employment growth	-0,49*												
		Change in manufacture	0,06												
		Per capita income growth	-0,94*												
Change 90-10 logarithm weekly wage differential	U.S. MSA, 103 in 1970; 220 in 1980 and, 226 in 1990	Change in manufacture	-0,73*	1970-1990	TSLs + regions effects# (also without region effects)	Logarithm initial per capita income growth	-	-	-						
		Change in manufacture	-0,73*												

Source: Own Elaboration. Note: \*statistically significant, #reported results

**Table 2c. Studies addressing endogeneity in the estimation of agglomeration economies**

Author(s)	Main variable to be explained / Industry	Spatial Unit	Agglomeration Indicator	Elasticity or Gradient ( $\beta$ )	Time period	Estimation method	Main Instrument used	Instruments Test		Ratio of estimates ( $\beta_{IV}/\beta_{LS}$ )	
								Relevance	Exogeneity-Validity		
Fingleton (2006)	Local wage variations (wage rates)	NEG model	Market potential	0,156*	2000	TSLSh / ML (spatial lag model)	Endogenous lag	-	-	-	
			Spillover nearby areas	0,0174*							
			Employment density	0,0139*							
			Spillover nearby areas	0,00142*							
			Market potential	0,0386							
ANM model (artificial nesting model)	Employment density	0,0139*									
	Spillover nearby areas	0,001776*									
Kim (2006)	Average annual wage	U.S. individual firms county level information (4285 in 1850, 3536 in 1860, 2280 in 1870, 8658 in 1880 and 8658 in 1880*)	Urban 1850	0,47*	1850-1880	OLS / IV estimation#	1) Share of the county population that was urban in 1840	F-statistic	Sargan Test (validity)	4,70	
			Urban 1860	0,22*			1) share of the county population that was urban in 1850, 2) access to water transportation, 3)			3,14	
			Urban 1870	0,83*			distance to the eastern seaboard and 4) county date of incorporation			4,15	
			Urban 1880	0,78*						2,05	
			Urban 1880*adjusted 5 months	0,52*						1,93	
			% Urban > 2500 1850	0,23*							
			% Urban > 25000 1850	0,23*							
			Population 1850	0,03*							
			Population density 1850	0,03*							
			% Urban > 2500 1860	0,25*							
			% Urban > 25000 1860	0,26*							
			Population 1860	0,06*							
			Population density 1860	0,05*	1850-1880	IV estimation	1) share of the county population that was urban in 1850, 2) access to water transportation, 3)				
			% Urban > 2500 1870	0,51*			distance to the eastern seaboard and 4) county date of incorporation				
			% Urban > 25000 1870	0,45*							
Population 1870	0,11*										
Population density 1870	0,06*										
% Urban > 2500 1880	0,28*										
% Urban > 25000 1880	0,37*										
Population 1880	0,14*										
Population density 1880	0,09*										
Rice et al., (2006)	Average hourly earnings per employee	119 out of 126 Great Britain NUTS-3 regions	population working age within 40 min travel time	0,0584*	1998-2001	OLS (with and without regional dummies), ML (spatial lag model), IV estimation# (with regional dummies)	1.1-1.5) 1851 population in the area within 10, 20, 40, 50 and 80 miles and, 2.1-2.2) share of economic active population with degree and with no formal education qualifications	F-statistic	-	1,14	
			population within 40-80 min travel time	0,0133*						0,89	
	Average hourly earnings per employee (spatial decay)	119 out of 126 Great Britain NUTS-3 regions	population within 80-120 min travel time	0,0070							0,19
			Economic mass (population)	0,0698*	1998-2001	NLS (non-linear least squares), IV estimation# (with regional dummies)					1,45
Rate of decay (effects decline with distance)	1,2045*									0,85	

Source: Own Elaboration. Note: \*statistically significant, #reported results



**Table 2d. Studies addressing endogeneity in the estimation of agglomeration economies**

Author(s)	Main variable to be explained / Industry	Spatial Unit	Agglomeration Indicator	Elasticity or Gradient ( $\beta$ )	Time period	Estimation method	Main Instrument used	Instruments Test		Ratio of estimates ( $\beta_{IV}/\beta_{LS}$ )	
								Relevance	Exogeneity-Validity		
Wheeler (2006)	Wage growth (in annual rates)	1258 observations, male workers who held 5150 jobs, represented by 385 local labour markets	Population	0,0022*	1994	OLS	initial conditions	-	-	-	
			Population density	0,0026*							
			Diversity	0,0041*							
Yankow (2006)	Regional CPI hourly wage. Without controlling cost of living	3490 young men contributing 23.956 wage observations. National Longitudinal Survey of Youth 1979	Big city (MSA with population>1 million)	0,175*	1994	OLS# (industry, occupation and firm size controls) / FE / FE + experience effects	initial conditions	-	-	-	
			Small city (>250.000 but less than <1.000.000)	0,076*							
	Full cost-of-living-adjusted CPI-deflated hourly wage	3490 young men contributing 23.956 wage observations. National Longitudinal Survey of Youth 1979	Big city (MSA with population>1 million)	0,044**							
			Small city (>250.000 but less than <1.000.000)	0,051*							
	Annual change in wages	3490 young men contributing 23.956 wage observations. National Longitudinal Survey of Youth 1979	$\Delta$ city (population)	0,059*							
			City (population)	0,013*							1979-1994
			In-City (population)	0,061*							$\Delta \ln W(t+1)$
			Out-City (population)	-0,069*							
			City (population)	0,007							1979-1994
			In-city (population)	0,111*							$\Delta \ln W(t+4)$
	Wage level specifications	3490 young men contributing 23.956 wage observations. National Longitudinal Survey of Youth 1979	Out-City (population)	0,009							
			City (population)	0,187*							1979-1994
			In-city (population)	0,039							$\ln W(t)$ . Wage level prior to move
			Out-City (population)	-0,108*							
City (population)			0,194*	1979-1994							
In-city (population)			0,088*	$\ln W(t+1)$ . Wage level in the following year							
Difference in wages across jobs adjusted for within-job wage growth	3490 young men contributing 23.956 wage observations. National Longitudinal Survey of Youth 1979	Out-City (population)	-0,178*								
		City (population)	0,188*	1979-1994							
		In-city (population)	0,170*	$\ln W(t+4)$ . Wage earned four years after to move							
		Out-City (population)	-0,122*								
Difference in wages across jobs adjusted for within-job wage growth	3490 young men contributing 23.956 wage observations. National Longitudinal Survey of Youth 1979	Big city (MSA with population>1 million)	0,090*	1979-1994							
		Small city (>250.000 but less than <1.000.000)	0,082*								
		Non-urban (<250.000)	0,079*								
			Rural (<100.000)	0,066*							

Source: Own Elaboration. Note: \*statistically significant, #reported results

**Table 2e. Studies addressing endogeneity in the estimation of agglomeration economies**

Author(s)	Main variable to be explained / Industry	Spatial Unit	Agglomeration Indicator	Elasticity or Gradient ( $\beta$ )	Time period	Estimation method	Main Instrument used	Instruments Test		Ratio of estimates ( $\beta_{IV}/\beta_{LS}$ )
								Relevance	Exogeneity-Validity	
Graham and Kim (2008)	Aggregate wage in 9 industries	10.780 Britain wards	Employment density. Manufacturing	0,031*	1995-2002	Non-linear SURE estimator	No instruments variables, two stage procedure: 1) estimating the error variance matrix using nonlinear least squares, and 2) estimating the parameters that minimizes the generalized sum of the squares for the system as a whole	-	-	-
			Employment density. Construction	-0,013						
			Employment density. Distributions and hotels	0,146*						
			Employment density. Transport and storage	0,021*						
			Employment density. Real estate	0,111*						
			Employment density. IT	0,039*						
			Employment density. Banking and finance	0,060*						
			Employment density. Business services	-0,016*						
			Emplotment density. Public services	-0,013*						
			Wheeler (2008)	Variance of income distribution for metropolitan area						
Percent manufacturing	-0,35*									
Percent agriculture	-0,04									
Percent construction	-0,28*									
Percent wholesale trade	-0,10									
Percent retail trade	0,11									
Percent FIRE	-0,46*									
Percent public adm.	-0,34*									
Percent education serv.	-0,28*									
Percent health services	0,11									
Changes within neighbourhood income variation	359 U.S. MA (metropolitan areas). 165.000 block groups for 1980, 1990 and 2000 (718 observations)	Population density		-0,064*						
		Percent manufacturing		-0,27*						
		Percent agriculture		-0,13						
		Percent construction		0,035						
		Percent wholesale trade		0,10						
		Percent retail trade		0,03						
		Percent FIRE		-0,26*						
		Percent public adm.		-0,18						
		Percent education serv.		0,12						
		Percent health services		0,02						
Changes between neighbourhood income variation	359 U.S. MA (metropolitan areas). 165.000 block groups for 1980, 1990 and 2000 (718 observations)	Population density	0,006							
		Percent manufacturing	-0,08							
		Percent agriculture	0,09							
		Percent construction	-0,32*							
		Percent wholesale trade	-0,19							
		Percent retail trade	0,08							
		Percent FIRE	-0,20							
		Percent public adm.	-0,16							
		Percent education serv.	-0,39*							
		Percent health services	0,09							

Source: Own Elaboration. Note: \*statistically significant, #reported results

**Table 2f. Studies addressing endogeneity in the estimation of agglomeration economies**

Author(s)	Main variable to be explained / Industry	Spatial Unit	Agglomeration Indicator	Elasticity or Gradient ( $\beta$ )	Time period	Estimation method	Main Instrument used	Instruments Test		Ratio of estimates ( $\beta$ IV/ $\beta$ LS)
								Relevance	Exogeneity-Validity	
Wheeler (2008)	Variance of income for metropolitan area	359 U.S. MA (metropolitan areas). 165.000 block groups for 1980, 1990 and 2000 (718 observations)	Population density	-0,04	1980-2000	IV estimation# / OLS	Logarithm density 1980	F-statistic	Sargan Test (validity)	0,57
	Changes within neighbourhood income		Population density	-0,04			Industry employment shares 1980			0,57
	Changes between neighbourhood income		Population density	-0,066*			Logarithm density 1980			1,03
	Unweighted 90th percentile		Population density	-0,07*			Industry employment shares 1980			1,09
	Unweighted 50th percentile		Population density	0,02			Logarithm density 1980			3,33
	Unweighted 10th percentile		Population density	0,03			Industry employment shares 1980			5,00
	Weighted 90th percentile		Population density	0,02			Logarithm density 1980			0,12
	Weighted 50th percentile		Population density	0,01			Industry employment shares 1980			0,06
	Weighted 10th percentile		Population density	0,15*			Logarithm density 1980			1,50
	Within component		Population density	0,16*			Industry employment shares 1980			1,60
	Between component		Population density	-0,05			Logarithm density 1980			0,71
	Unweighted 90-10 percentile difference		Population density	0,09			Industry employment shares 1980			1,29
	Unweighted 90-50 percentile difference		Population density	-0,04			Logarithm density 1980			0,25
	Unweighted 50-10 percentile difference		Population density	-0,01			Industry employment shares 1980			0,06
	Weighted 90-10 percentile difference		Population density	0,12*			Logarithm density 1980			1,20
	Weighted 90-50 percentile difference		Population density	0,08			Industry employment shares 1980			0,80
	Weighted 50-10 percentile difference		Population density	-0,05			Logarithm density 1980			0,76
	Unweighted 90th percentile		Population density	-0,01			Industry employment shares 1980			0,15
	Unweighted 50th percentile		Population density	-0,06*			Logarithm density 1980			0,86
	Unweighted 10th percentile		Population density	-0,06*			Industry employment shares 1980			0,86
	Weighted 90th percentile		Population density	0,02			Logarithm density 1980			2,00
	Weighted 50th percentile		Population density	0,02			Industry employment shares 1980			2,00
	Weighted 10th percentile		Population density	0,05			Logarithm density 1980			0,63
	Median Census Tract. 1649 households		Population density	-0,25			Industry employment shares 1980			3,13
	Unweighted 90th percentile		Population density	-0,11			Logarithm density 1980			1,57
	Unweighted 50th percentile		Population density	-0,15			Industry employment shares 1980			2,14
	Unweighted 10th percentile		Population density	0,16			Logarithm density 1980			22,86
	Weighted 90th percentile		Population density	-0,10			Industry employment shares 1980			14,25
	Weighted 50th percentile		Population density	-0,05			Logarithm density 1980			0,56
	Weighted 10th percentile		Population density	-0,17			Industry employment shares 1980			1,89
	Unweighted 90th percentile		Population density	-0,08			Logarithm density 1980			1
	Unweighted 50th percentile		Population density	-0,21*			Industry employment shares 1980			2,63
Unweighted 10th percentile	Population density	0,03	Logarithm density 1980	3,00						
Weighted 90th percentile	Population density	0,04	Industry employment shares 1980	4,00						
Weighted 50th percentile	Population density	0,01	Logarithm density 1980	0,05						
Weighted 10th percentile	Population density	-0,04	Industry employment shares 1980	0,21						
Unweighted 90th percentile	Population density	0,12*	Logarithm density 1980	1,09						
Unweighted 50th percentile	Population density	0,10*	Industry employment shares 1980	0,91						
Unweighted 10th percentile	Population density	-0,04	Logarithm density 1980	0,36						
Weighted 90th percentile	Population density	0,21*	Industry employment shares 1980	1,91						
Weighted 50th percentile	Population density	-0,01	Logarithm density 1980	0,06						
Weighted 10th percentile	Population density	-0,11	Industry employment shares 1980	0,65						
Unweighted 90th percentile	Population density	0,07	Logarithm density 1980	0,88						
Unweighted 50th percentile	Population density	0,10*	Industry employment shares 1980	1,25						
Unweighted 10th percentile	Population density	0,05	Logarithm density 1980	0,71						
Weighted 90th percentile	Population density	0,07	Industry employment shares 1980	1,00						

Source: Own Elaboration. Note: \*statistically significant, #reported results

**Table 2g. Studies addressing endogeneity in the estimation of agglomeration economies**

Author(s)	Main variable to be explained / Industry	Spatial Unit	Agglomeration Indicator	Elasticity or Gradient ( $\beta$ )	Time period	Estimation method	Main Instrument used	Instruments Test		Ratio of estimates ( $\beta$ IV/ $\beta$ LS)
								Relevance	Exogeneity-Validity	
Combes et al., (2008)	Whole economy, local wage index (area-year fixed effects)	341 French employment areas	Density local emplmnt	0,0302*	1976-1998	IV estimation# / OLS (2) / FGLS / OLS + fixed effects (2)	1) Population density 1831, 2) Population density 1861, 3) Population density 1891, 4) Population density 1921 and, 5) Market potential 1831	R <sup>2</sup>	Sargan Test	0,937
			Diversity	-0,407*						8,847
			Market potential	0,0244*						0,695
Di addario and Patacchini (2008)	Employees hourly wages rates from primary activities deflated with the consumer price index (CPI) for blue-collar worker and households	242 Italian local labor markets	Local labour market population	0,0132*	1995-2002	IV estimation# / OLS	1) share of LLM area destined to agriculture, 2) amount of land covered by marsh and 3) amount of land covered by water	F-statistic	Sargan Test / Hansen Test	0,59 / 1,59
			Population mass 0-4km	0,0098*	1995-2002	OLS	initial conditions	-	-	-
			Population mass 4-8km	0,0041*						
			Population mass 8-12km	0,0016*						
			Population mass 12-16km	0,0002						
Local labour market population	0,0105 / 0,2235*									
Melo and Graham (2009)	Real net hourly earnings in 12 2-digit SIC industries: 1) primary, 2) manufacturing, 3) electricity, gas & water, 4) construction, 5) wholesale&retail, 6) hotels&restaurants, 7) transportation&storage, 8) financial intermediation, 9) real state, 10) renting, IT, R&D, 11) other business activities and, 12) public services	U.K. TTWA (travel-to-work areas)	Firm size	0,0060*	2002-2006	IV instruments# / POLS / BE / RE / FE(1) / FE(2) / FD / HT	1) Population density and, 2) Market Potential	F-statistic / partial R <sup>2</sup> / Shea partial R <sup>2</sup>	Hansen J stat	0,43
			Employment density	0,0079*						0,36
			Market potential	0,0578*						0,58
			Industrial specialization	-0,0049						4,08
			Economic diversity	-0,0074*						0,14
			Firm size	0,054*						0,39
			Employment density	0,0067*						0,30
			Market potential	0,0431*						0,43
			Industrial specialization	-0,0067						5,58
			Economic diversity	-0,008*						0,16
Melo and Graham (2009)	Real net hourly earnings in 12 2-digit SIC industries: 1) primary, 2) manufacturing, 3) electricity, gas & water, 4) construction, 5) wholesale&retail, 6) hotels&restaurants, 7) transportation&storage, 8) financial intermediation, 9) real state, 10) renting, IT, R&D, 11) other business activities and, 12) public services	U.K. TTWA (travel-to-work areas)	Firm size	-0,016*primary/ 0,021*manf	2002-2006	IV instruments# / POLS / BE / RE / FE(1) / FE(2) / FD / HT	1) Population density and, 2) Market Potential	F-statistic / partial R <sup>2</sup> / Shea partial R <sup>2</sup>	Hansen J stat	-
			Employment density	-0,0103*whsle/ /0,036*RITR&D						
			Market potential	0,054*whsle/ 0,111*transp						
			Industrial specialization	0,039*whsle/ 0,097*financl						
			Economic diversity	-0,042*RITR&D/ -0,084*electrcy						
			Firm size	-0,045*primary/ 0,184*manf						
			Employment density	-0,0166*whsle/ /0,175*realste						
			Market potential	0,071*whsle/ 0,129*financl						
			Industrial specialization	0,0493*whsle/ 0,088*financl						
			Economic diversity	-0,044*RITR&D/ -0,013*electrcy						

Source: Own Elaboration. Note: \*statistically significant, #reported results

**Table 2h. Studies addressing endogeneity in the estimation of agglomeration economies**

Author(s)	Main variable to be explained / Industry	Spatial Unit	Agglomeration Indicator	Elasticity or Gradient ( $\beta$ )	Time period	Estimation method	Main Instrument used	Instruments Test		Ratio of estimates (BIV/BLS)			
								Relevance	Exogeneity-Validity				
Glaeser et al., (2009)	Income growth	258 U.S. MSA (metropolitan statistical areas)	Population 1980	0,275*	1980-2000	OLS	initial conditions	-	-	-			
			Median income family 1980	-0,4195*									
	Gini coefficient (pretax income inequality)	242 U.S. MSA (metropolitan statistical areas)	Population 1980	0,6189*	2006	OLS	initial conditions	-	-	-			
			Median income family 1980	0,0037*									
	Gini coefficient (pretax income inequality)	258 U.S. MSA (metropolitan statistical areas)	Population 1980	0,055*	1980	OLS	no instrument variables	-	-	-			
			Median income family 1980	-0,1078*									
Gini coefficient (pretax income inequality)	282 U.S. MSA (metropolitan statistical areas)	Population 2000	0,005*/0,008*	2000	OLS	no instrument variables	-	-	-				
		Median income family 2000	-0,0392* / -0,0447*										
Combes et al., (2010)	Whole economy, local wages	306 French employment areas	Employment density	0,026* / 0,042*	1976-1996	OLS / TSLS#	1) Population density 1831, 2) Population density 1881	R <sup>2</sup>	Sargan Test (validity)	0,86 / 0,78			
				0,038* / 0,047* / TSLS		TSLS# / LIML# (limited information maximum likelihood)	1) Subsoil mineralogy, 2) Ruggedness, 3) Depth to rock, 4) Soil carbon content, 5) Topsoil water capacity and, 6) Dominant parent material						
			Employment density	0,038* / 0,050* / LIML	1976-1996	GMM# / TSLS#	1) Pop. density 1831, 2) Subsoil mineralogy, 3) Ruggedness, 4) Hydrogeological class and 5) Topsoil water capacity						
				0,027* / GMM									
			Employment density	0,027* / 0,042* / TSLS	1976-1996	OLS / TSLS#	1) Pop. density 1831, 2) Subsoil mineralogy, 3) Ruggedness, 4) Subsoil water, 5) Depth to rock, 6) Erodibility, and 7) Soil diff.						
			Market potential	0,034*									
Graham et al., (2010)	11 sector industries wages: 1) manufacture, 2) construction, 3) wholesale-retail, 4) hotels-restaurants, 5) transport, 6) finance, 7) real estate, 8) information-technology, 9) business-management, 10) other public services and, 11) public services	60263 UK individual firms, data aggregated at PCS (post code sector)	Urb.Eco. Markt Potntial	0,132* / 0,117 / 0,145* / 0,206* / 0,251* / 0,747* / 0,825 / - / 0,441* / 0,289* / 0,092	1996-2004	DIFF-GMM. Dynamic VAR models, Granger causality	GMM (lags t-2)	F-statistic	Sargan Test and Hansen Test (validity)	-			
				0,269* / 0,073 / 0,028* / 0,078* / 0,073* / 0,192* / 0,258 / - / 0,148* / 0,102* / 0,066									
			Loc.Eco. Distnce Bands										

Source: Own Elaboration. Note: \*statistically significant, #reported results

**Table 2i. Studies addressing endogeneity in the estimation of agglomeration economies**

Author(s)	Main variable to be explained / Industry	Spatial Unit	Agglomeration Indicator	Elasticity or Gradient ( $\beta$ )	Time period	Estimation method	Main Instrument used	Instruments Test		Ratio of estimates (BIV/BLS)	
								Relevance	Exogeneity-Validity		
Goetz et al., (2010)	All industries, income per capita by place of residence	U.S. Counties	Population density	0,054*	2000-2007	OLS	Initial conditions	-	-	-	
			Industry entropy	-0,261*							
			In-degree	0,157*							
			Out-degree	-0,247*							
			In-*out-degree	0,072							
			In-entropy	-0,198*							
	All industries, earnings per job by place of work	U.S. Counties (inter-urban)	Population density	-0,001	2000-2007	OLS	Initial conditions	-	-	-	
			Industry entropy	-0,177*							
			In-degree	0,219*							
			Out-degree	-0,136							
			In-*out-degree	-0,040							
			In-entropy	0,083							
Glaeser et al., (2012)	Income growth	1328 U.S. counties	Population 1950	-0,0868*	1950-2000	OLS	Initial conditions	-	-	-	
			Share manufacture 1950	0,305*							
			Median income 1950	-0,7392*							
	Change in median income	1336 U.S. counties	Population 1950	0,001	1980-2000	OLS	Initial conditions	-	-	-	
			Share manufacture 1950	0,390*							
			Median income 1950	-0,065*							
		444 U.S. counties (>50.000 population)	Population 1950	0,008							
			Share manufacture 1950	0,434*							
			Median income 1950	0,062							
	Lee et al., (2013)	Theil income inequality index (level of income inequality among municipalities)	533 municipalities in 21 counties of 9 PMSAs (primary metropolitan statistical areas) of New Jersey State	Per capita income	3,3E-06*	1970-2009	GLS+ random effect	Panel data reference year 1990			
		Per capita income (ratio between total household income and total population)	533 municipalities in 21 counties of 9 PMSAs of New Jersey State	Population density 1980	-0,188*	2009	Spatial Error Model (SEM)	Initial conditions	-	-	-
				Population growth 1980-2009	-18,133*						
Per capita income 1980				1,677*							
Per capita income change		533 municipalities in 21 counties of 9 PMSAs of New Jersey State	Population density 1980	-0,001	1980-2009	Spatial Error Model (SEM)	Initial conditions	-	-	-	
			Population growth 1980-2009	-0,272*							
			Per capita income 1980	-0,022*							
Per capita property tax base		533 municipalities in 21 counties of 9 PMSAs of New Jersey State	Population density 1980	0,000	2005	Spatial Lag Model (SLM)	Initial conditions	-	-	-	
			Population growth 1980-2009	-0,001*							
			Per capita income 1980	0,653*							
Per capita property tax base rate		533 municipalities in 21 counties of 9 PMSAs of New Jersey State	Population density 1980	0,000*	1980-2005	OLS	Initial conditions	-	-	-	
			Population growth 1980-2009	-0,002*							
	Per capita income 1980		-0,601*								

Source: Own Elaboration. Note: \*statistically significant, #reported results

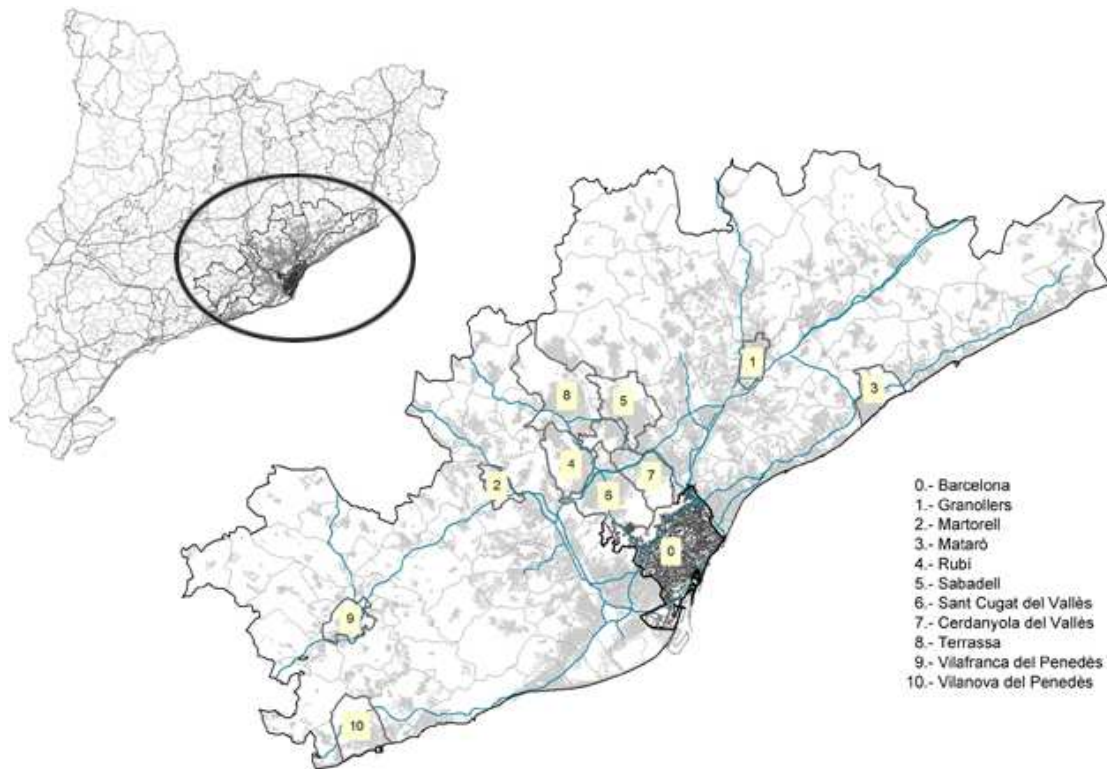
### 3. STUDY CASE: BARCELONA METROPOLITAN REGION

The Barcelona Metropolitan Region (BMR) (Figure 1) was delimited in 1966 by the Esquema Director de l'Àrea Metropolitana. Composed of 164 municipalities, the region covers an area of 323,000 ha and has a radius of 55 km. Currently, the Barcelona Metropolitan Region (BMR) is the second most dense urban area, the fourth most populated and the eighth most extensive in Europe. It generates 12 percent of Spain's GDP and more than 20 percent of Spanish exports. With over 65 percent of Catalonia's population (5.012.961 inhabitants out of 7.512.381 inhabitants in 2010) and employment (1.822.000 jobs out of 2.615.591 in 2001), the BMR is the main urban agglomeration in Catalonia.

The city of Barcelona (marked in dark in Figure 1) is the principle center in the region and the continuous built-up area surpasses its administrative limits, taking in 12 adjacent municipalities<sup>95</sup>. Five outlying municipalities (Mataró, Terrassa, Sabadell, Vilafranca del Penedès and Vilanova i la Geltrú) are medium-sized towns that in the past accounted for a significant proportion of the services consumed by nearby towns. Today, these towns still have a high level of self-containment and a net balance of entries in journeys due to work or study. The demographic dynamic that has driven the consolidation of the current Barcelona metropolitan territory is based on three main stages. Firstly, the Barcelona Metropolitan Region increased twice its population due to a significant immigration process started at the beginnings of the 1950s. Thus, the resident population was 1.966.291 in 1950 and 4.238.876 in 1981. Secondly, a second stage begun in the late 1970s with the generalized economic crisis which caused that the new arrivals of immigrants highly decreased. As a result, during this second stage that took approximately two decades, the Barcelona's metropolitan population maintained stable, around 4,2 million inhabitants. Since then, a great variety of centrifugal forces that had been accumulated during the previous stage, for example the saturation of the urban areas that most had been grown, took advantage of the progressive increments of accessibility and consequently, entailing a suburbanization process towards the rest of the metropolitan territory. Thus, during second period, because of population and employment decentralization towards other metropolitan cities have meant that many firms have moved towards the outskirts in search of access to main roads, originating the emerging of other important nodes within the BMR, including Granollers, Martorell, Rubí, Sant Cugat del Vallès and Cerdanyola del Vallès (see, Figure 1). This urban trend, conjointly with the re-entry of new immigrant population (until 2006), has become the pillars to understand the urban cycle that drives the last stage (since late 1990s) of the Barcelona's metropolitan demographic development, allowing its population to get out of the population standstill and earning critical mass until 4.841.365 inhabitants in 2006 and 5.012.961 in 2010. To address and articulate this new metropolitan territory, the Generalitat de Catalunya (autonomous government of Catalonia) has approved in 2010, el Pla Territorial Metropolità de Barcelona (PTMB) with the purpose to organize the territory of the BMR in order to contribute to articulate a metropolitan territory in accordance with the objectives of economic efficiency, social equity and environmental sustainability. In this sense, the PTMB define the Barcelona Metropolitan Region as a system of networked cities defined by the central city of Barcelona, the five main aforementioned medium-sized cities of Mataró, Terrassa, Sabadell, Vilafranca del Penedès and Vilanova i la Geltrú and, the emerged metropolitan nodes of Martorell and Granollers since 1990s. According to the PTMB, in this way, this polycentric structure permits to develop dense and compact cities, efficiently connected but with the necessary distance between them to guarantee the preservation of the natural environment.

<sup>95</sup> Badalona, Cornellà del Llobregat, Esplugues de Llobregat, L'Hospitalet de Llobregat, Montgat, El Prat de Llobregat, Sant Adrià del Besòs, Sant Boi de Llobregat, Sant Feliu de Llobregat, Sant Joan Despí, Sant Just Desvern and Santa Coloma de Gramanet.

**Figure 1. The Barcelona Metropolitan Region within the Catalan territory**



Source: Own Elaboration

### 3.1. Defining the urban spatial structure

The procedure of defining the urban spatial structure at intra-metropolitan scale is based on identifying the subcentres that are within in. In this sense, during the last 20 years many empirical studies about polycentricity have been proposed methodological procedures to identify subcentres. In our case, we borrow the identification methodology proposed by the same author of this work in (Masip, 2012a). Its approach is suitable for identifying subcentres that are within the bid-rent theoretical tradition based on the process of employment decentralization from a single and congested Central Business District (CBD) and also is suitable for the hierarchical and complex European urban systems where centers mostly emerged as a result of the integration or coalescence of pre-existing cities. In this way, Masip's approach takes into account the morphological and the functional characteristics of nodes (municipalities) according to the different dimensions that polycentricity is based on as the specialized literature suggests. In addition, the procedure is able to characterize the subcentres that are “places to work” (employment sub-centers) and sub-centres that are “places to work and live” (urban sub-centers). That means distinguishing between those sub-centers that only attract workers (in-commuting flows) or retain their resident workers from those sub-centers that are able to attract flows and retain their resident employed population at the same time. According to Masip's work the former group of subcentres is characterized as emerging subcentres and the latter one as large subcentres. To identify them, Masip's procedure is based in three steps: a) first, it adopts a functional perspective in keeping with the European urban system paradigm by analyzing the commuting flows in a residence-to-work matrix, RW (resident workers) Entropy Information and the IF (in-commuting flows) Entropy Information has been calculated for all municipalities. These indicators proposed by (Masip, 2012a) approximate which municipalities are the most hierarchical and complex in terms of the local



labor market (RW-resident workers) and attracting a substantial number of commuters (IF-incommuting flows)<sup>96</sup>. In other words, according to Masip's study the municipalities that best fit the European urban systems paradigm, then b) secondly, it identifies the positive residuals estimated from an exponential RW Entropy Information function and from an exponential IF Entropy Information function<sup>97</sup> and finally, c) the third step of Masip's methodology consists of selecting the positive residuals of the two Employment Entropy functions: the municipalities that have positive residuals in these two Employment Entropy functions are defined as sub-centers and they are simultaneously categorized using the following criteria: 1) municipalities with both residuals in RW and IF Entropy Information are categorized as large subcentres and 2) ones with positive residuals in RW or IF Entropy Information are classified as emerging subcentres. After applying its approach to identify subcentres and compared to other density standard methodologies, (Masip, 2012a:26) present that: *“results suggest that compared to identifying sub-centers using standard density models, the municipalities identified as sub-centers using this new procedure are more dominant in the mobility flows, more self-contained, and their influence on the urban structure are more significant entailing a better explanation of employment density”* and its study identifies, 8, 11 and 12 subcentres in the Barcelona Metropolitan Region from 1991 to 2001 respectively.

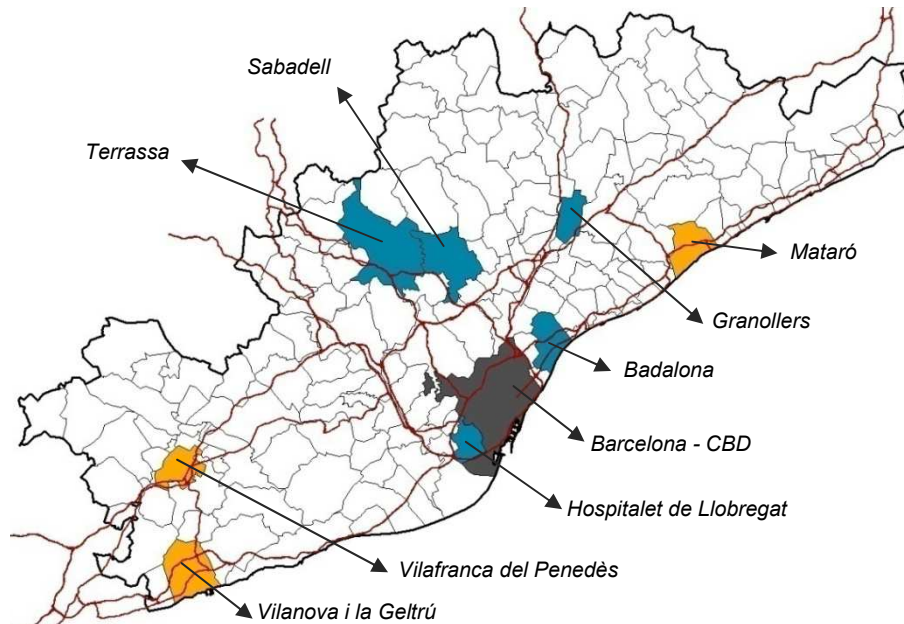
The following (Figures 2a, 2b and; 2c) show the subcentres that Masip's study has identified in the Barcelona Metropolitan Region from 1991 to 2001. In addition the Figures highlight the process of subcentres emergence linked to the infrastructure nodes (Martorell, Rubí) as well as in the north of the CBD-Barcelona (Sant Cugat del Vallès and Rubí). According to (Masip, 2012a:17) this process of emergence has been more significant from 1991 to 1996 than 1996 to 2001 (during the period of 1991 to 1996 there was an increment of three identified subcentres, meanwhile from 1996 to 2001 this increment it was only one subcentre) at the time that the subcentres identified as “emerging” are the subcentres that most increased their LTL (localised workplaces: resident workers and incommuting workers) in comparison

<sup>96</sup> To estimate the RW and IF Entropy Information, it is necessary according to (Masip, 2012a) to use the following two equations:  $EI_{RW} = -\sum_{i=1}^n (RW_i \cdot [Ln(RW_i)])$  and  $EI_{IF} = -\sum_{i=1}^n (IF_i \cdot [Ln(IF_i)])$ , where  $(RW_i \cdot [Ln(RW_i)])$  and  $(IF_i \cdot [Ln(IF_i)])$  are the RW Entropy Information and IF Entropy Information for each municipality, and  $EI_{RW}$  and  $EI_{IF}$  are the RW Entropy Index and IF Entropy Index for the entire metropolitan area. The higher the RW Entropy Information and IF Entropy Information for municipality (i), the greater the weight of municipality (i) in terms of RW and IF relative to entire metropolitan area because  $RW_i$  and  $IF_i$  are the probability (proportion) of observing RW and IF in municipality (i). As a consequence, (Masip, 2012a:14) states that: *“the higher the RW (resident workers) Entropy Information is for a given municipality, the greater its functional urban hierarchy and complexity with respect to the local labor market. Thus, the greater the capacity a given municipality has to retain its labor force and be functionally autonomous from other urban nodes. For the same reason, the higher IF (in-commuting flows) Entropy Information is for a given municipality, the greater its capacity to attract workers and be an important employment node in the metropolitan area”*. Thus, after the RW and IF Entropy Information are separately calculated, Masip's study observes two types of municipalities: (1) municipalities that have a higher value of RW and IF Entropy Information. Thus, these urban nodes have a hierarchical local labor market, meaning that they are able to retain their labor force and be attractive enough in residential terms to increase population. In addition, these nodes attract workers from a variety of other urban nodes in the metropolitan area and, (2) municipalities that have a higher value of RW or IF Entropy Information. Thus, these nodes are functionally hierarchical in terms of their local labor markets or have a higher capacity to attract workers. In other words, these nodes are important “places to work”.

<sup>97</sup> These double exponential Employment Entropy Information functions as Masip's study suggests can be formulated as follows:  $RW(EI)Inf_x = C + \beta Dist_{x-CBD}$  and  $IF(EI)Inf_x = C + \beta Dist_{x-CBD}$ , where  $RW(EI)Inf_x$  and  $IF(EI)Inf_x$  are the RW and IF Entropy Information in municipality (x), C is a constant that is assumed to be the RW and IF Entropy Information at the CBD and  $Dist_{x-CBD}$  is the distance between the CBD and the municipality (x). Therefore (Masip, 2012a:15) points out that: *“the proposed procedure to identify sub-centers includes methodology employed by North American studies to identify sub-centers. By computing the RW and IF Entropy Informations for each municipality as function of the distance to the CBD, the procedure adopts a morphological methodology that is based on the bid-rent theoretical tradition”*.

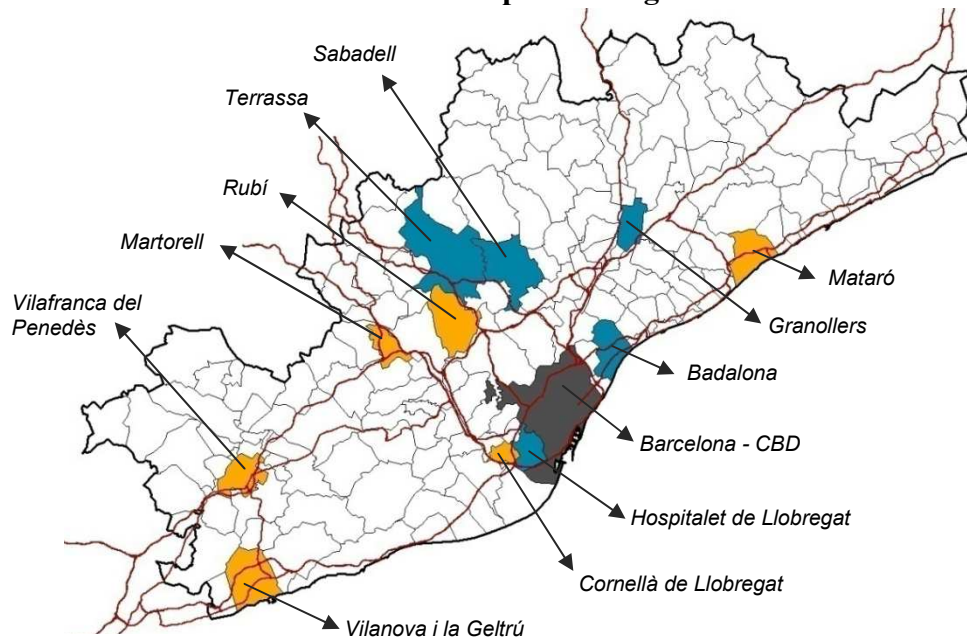
with their LTL in 1991. These are the cases of Martorell (139,67%), Sant Cugat del Vallès(86,04%), El Prat de Llobregat (38,11%). Otherwise, the “large-consolidated” subcentres have had a more constant LTL increment: for example Sabadell 10,19%, Terrassa 26,05%, Badalona 10,57%, L’Hospitalet de Llobregat 4,08%.

**Figure 2a. Sub-centres (large and emerging) identified by (Masip, 2012a) for the Barcelona Metropolitan Region in 1991**



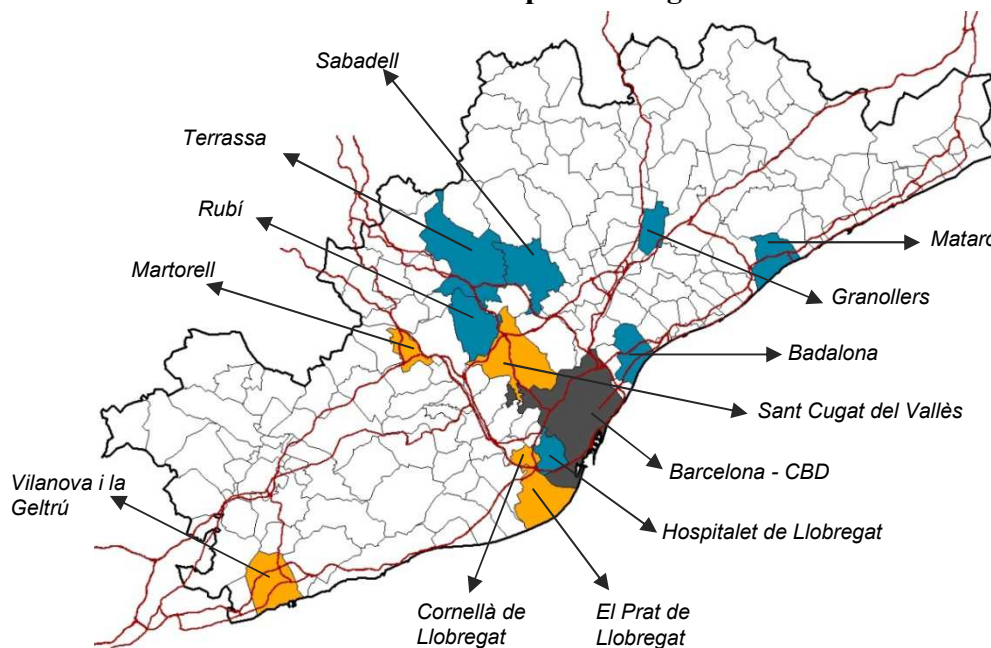
Source: (Masip, 2012a). Note: the emerging subcentres are marked in orange and the large ones in blue.

**Figure 2b. Sub-centres (large and emerging) identified by (Masip, 2012a) for the Barcelona Metropolitan Region in 1996**



Source: (Masip, 2012a). Note: the emerging subcentres are marked in orange and the large ones in blue.

**Figure 2c. Sub-centres (large and emerging) identified by (Masip, 2012a) for the Barcelona Metropolitan Region in 2001**



Source: (Masip, 2012a). Note: the emerging subcentres are marked in orange and the large ones in blue.

#### **4. EMPIRICAL FRAMEWORK: THE CAUSES AND CONSEQUENCES OF URBAN INEQUALITY**

In this section, the paper tests empirically the relationships between urban spatial structure by means of sub-centre influence according to its different nature: all, large and emerging as it has proposed by (Masip, 2012a) and other spatial and non-spatial characteristics with social equity through examining a) the causes of per capita income in 2008 and, b) the consequences of per capita income growth between 2001 and 2008 in the Barcelona Metropolitan Region.

##### **4.1. Research design**

Starting from the mainly previous contributions of the literature as regards the effect of agglomeration economies on wages or incomes (Carlino, 1985; Carlino and Voith, 1992; Graham, 2000; Glaeser and Maré, 2001; Wheeler, 2001, 2004, 2006, 2008; Kim, 2006; Rice et al., 2006; Yankow, 2006; Graham and Kim, 2008; Combes et al., 2008, 2010; Melo and Graham, 2009; Graham et al., 2010 and; Glaeser and Resseger, 2010), and the background research related to the return of education and earnings functions (Dahl, 2002; Peri, 2002; Fingleton, 2003, 2006; Moretti, 2004; Berry and Glaeser, 2005; Black et al., 2008; Rosenthal and Strange, 2008 and; Autor and Dorn, 2010), we adopt the wage or income functions and models proposed by (Glaeser et al., 1992, 1995; Glaeser and Saiz, 2003; Glaeser and Shapiro, 2005; Glaeser et al., 2009; Goetz et al., 2010; Glaeser et al., 2012 and; Lee et al., 2013).

These works, and in particularly (Glaeser et al., 2009), define the causes and consequences of urban inequality as the determinants that are able to explain the level of wage and/or income (i.e. employees hourly wages, per capita income and median family income) in a given point of time (t) and the factors that are statistically significant associated with the prediction of its

growth in a given period of time (t, t+1) respectively. In this way, these studies present the following general equations:

$$\text{Ln} (Y_{i,t}) = \beta_0 + \beta_1 X_{i,t-1} + \varepsilon_i \quad (1)$$

$$\text{Ln} \left( \frac{Y_{i,t}}{Y_{i,t-1}} \right) = \beta_0 + \beta_1 X_{i,t-1} + \varepsilon_i \quad (2)$$

Where, ( $Y_{i,t}$ ) and ( $Y_{i,t-1}$ ) denotes the urban inequality indicator to being considered: i.e. per capita income, per capita income change rate, per capita property tax, employee hourly wage, etc..., in municipality (i) at time (t) and (t-1) respectively. The former is related to the causes of urban inequality and the latter is referring with their consequences. Next to this, ( $X_{i,t-1}$ ) is a vector of static and/or dynamic variables for demographic and socioeconomic conditions (i.e. total of population, non-white and hispanic population, age structure, educated population, per capita income, etc...), housing market constraints (i.e. average housing value) and, local taxes and public expenditures (i.e. municipal tax, governmental expenditures, etc...); in which all of them constructed in the initial year of the analysed time period (t-1) because of mitigating the possible endogeneity problem that arise between the dependent and the independent variables<sup>98</sup>. Finally, ( $\beta_0$ ) and ( $\varepsilon_i$ ) are the constant and the error term of the equations (1) and (2) correspondingly.

However, the previous general (equations 1 and 2), proposed by the aforementioned studies in the literature could not capture properly the effects of urban structure at intra-metropolitan scale. This means that the previous urban inequality models should permit to capture the effects of agglomeration economies at different geographical scales (i.e. at local scale and at metropolitan scale) such as the work of (Rosenthal and Strange, 2004) has suggested. In this sense, there are no studies in the literature that attempt to capture the effects of agglomeration economies on urban inequality through defining the urban structure as a perfect polycentric spatial model (agglomeration economies that emerge from CBD and from the sub-centres). To the best of our knowledge, the only works in the literature that tries to find out the relationship between urban structure and urban inequality are the research conducted by (Glaeser, 2000) and (Glaeser et al., 2008) in which define the urban structure by using a perfect monocentric model: only considering the effects of the agglomeration economies that arise from the proximity to the CBD. Consequently, as the aim of the present work is to investigate the influence of urban structure at intra-metropolitan scale on the causes and the consequences of urban inequality, we include in the previous (equations 1 and 2) variables related to urban structure that a) define properly a polycentric spatial structure and, b) capture

<sup>98</sup> As we pointed out in the previous Section 2.5 (see, Tables 2a-2i), there are several ways to address the endogeneity problem of agglomeration economies estimation and wages/incomes. One of these procedures is using lagged variables (minimum of 7-8 years) and estimating the regression models through OLS (ordinary least squares), SLM (spatial error model) and SEM (spatial error models) techniques. Other approaches are based on using IV estimation or GMM estimation. However, as the comparative analysis shows, regarding wages and agglomeration (Table 2a-2i), the results are not conclusive: it is not clear what procedure performs better in the estimation of agglomeration and wages, because of considerable differences between IV and OLS estimates arise, leading to the conclusion that some studies obtain IV estimates that are smaller than the respective LS ones at the time that other studies reach on the inverse result. In addition, some studies (Ciccone, 2002 and; Brühlhart and Mathys, 2008) state that if agglomeration does have an endogenous component, it does not appear to induces a substantial bias in estimates. As a consequence, in this work, we follow the approach which is based on using lagged variables (t-1), decision that is consistent with aforementioned studies of (Glaeser et al., 1992, 1995; Glaeser and Saiz, 2003; Glaeser and Shapiro, 2005; Glaeser et al., 2009; Goetz et al., 2010; Glaeser et al, 2012 and; Lee et al., 2013) among others.

the different geographical scale in which the agglomeration economies exert their effects. In addition, we also added to the previous (equations 1 and 2), variables for controlling the differences between municipalities as regards the geographical location and urban amenities. Hence, the following (equations 3 and 4) present the basis functional form of the regression models that we use in our further empirical analysis (Section 4.4), in order to examine the determinants of the causes and consequences of urban inequality:

$$\ln(Y_{i,t}) = \beta_0 + \beta_1 X_{i,t-1} + \beta_2 U_{i,t-1}^M + \beta_3 U_{i,t-1}^L + \alpha C_{i,t-1} + \varepsilon_i \quad (3)$$

$$\ln\left(\frac{Y_{i,t}}{Y_{i,t-1}}\right) = \beta_0 + \beta_1 X_{i,t-1} + \beta_2 U_{i,t-1}^M + \beta_3 U_{i,t-1}^L + \alpha C_{i,t-1} + \varepsilon_i \quad (4)$$

In which,  $(Y_{i,t})$  is the dependent variable for the causes of urban inequality model;  $(Y_{i,t-1})$  is the dependent variable for the consequences of urban inequality model;  $(X_{i,t-1})$  is a vector of static and/or dynamic variables for demographic and socioeconomic conditions;  $(U_{i,t-1}^M)$  is a vector of spatial structure variables that capture the effects of agglomeration economies at metropolitan scale (i.e. proximity to CBD and sub-centres);  $(U_{i,t-1}^L)$  is a vector of spatial structure determinants related to the local effects of agglomeration economies;  $(C_{i,t-1})$  is a vector of control determinants to capture the differences of geographical location and urban amenities within the metropolitan region and finally;  $(\beta_0)$  and  $(\varepsilon_i)$  are the constant and the error term of the equations (3) and (4) respectively. In our case, by considering the Barcelona Metropolitan Region as study case, because of the data availability; the dependent variables formulated in the previous (equations 3 and 4) which, will be used in the regression models (Section 4.4) to test the influence of urban structure on the causes and consequences of urban inequality, are defined as a) per capita income in 2008  $(Y_{i,t})$  and, b) per capita income between 2001 and 2008  $(Y_{i,t-1})$ . The data of per capita income comes from the database of “Renta familiar disponible bruta” (RFDB) which is provided by IDESCAT (Institut d’Estadística de Catalunya) at two levels of disaggregation: 1) for each municipality and, 2) per capita in each municipality at the time that this study has also used the database of ‘Estadística d’estructura salarial’, which also is provided by IDESCAT, at 2-digit level of detail (51 sectors based on CCAE93 sectoral classification and, 55 occupations based on CCO94 occupational classification) in 2002 and 2006.

#### 4.2. The spatial and non-spatial determinants of the causes and consequences of urban inequality: independent variables and hypothesis

The aim of this section is to present the spatial and non-spatial determinants and the hypothesis that this work has taken into account in order to examine its influence on the (1) per capita income (causes of urban inequality), and (2) per capita income growth (consequences of urban inequality). To do so, we adapt (Glaeser et al., 1992, 1995; Glaeser, 2000; Glaeser et al., 2001; Glaeser and Saiz, 2003; Glaeser and Shapiro, 2005; Glaeser et al., 2008; Glaeser et al., 2009; Goetz et al., 2010; Glaeser et al., 2012 and; Lee et al., 2013) empirical approaches. These works examine the dynamic agglomeration externalities on wages and/or incomes by using lagged explanatory variables to address the endogeneity issue that may arise from the estimation process of agglomeration economies<sup>99</sup>. Hence, the

<sup>99</sup> In our study we use lagged explanatory in 2001 to explain per capita income in 2008 and per capita income growth between 2001 and 2008. According to the literature, see Section 2 of this present work or the theoretical revision done by (Masip, 2012b), a lag of 7-8 years in the explanatory variables is enough.

hypothesis to be tested is that per capita income and per capita income growth are functions of urban spatial characteristics related to the agglomeration economies' effect at metropolitan and local scale, a set of sociodemographic variables and some non-spatial factors which can be grouped in the following categories:

The first one is polycentricity (regarding agglomeration economies associated with urban spatial structure: metropolitan effects) which according to the literature it could be defined on the basis of urban morphology (physical characteristics and distribution of activities) that cities have, in our case, municipalities, or on the basis of the functional relation that takes place in such cities (municipalities), which sometimes the literature refers to it as 'relational polycentricity' or 'functional polycentricity'. These two dimensions of polycentricity has studied in-depth in the work carried out by (Burger and Meijers, 2012) and more specifically by (Kloosterman and Musterd, 2001 and, Parr, 2004) and by (Hall and Pain, 2006; Green, 2007; de Goei et al., 2010; van Oort et al., 2010; Burger et al., 2011; Masip and Roca, 2012b and; Vasanen, 2012) respectively. Here, we take into account only the morphological dimension of polycentricity. Hence, from a morphological point of view, a polycentric structure by taking into account intra-metropolitan scale could be defined by means of sub-centres and CBD (central business district). To examine their metropolitan effects as (García-López and Muñiz, 2012) has proposed is necessary to measure the agglomeration economies (urbanization economies -diversity- and localization economies -specialized services-) that these nodes exert in the metropolitan area. To do so, in our case we compute separately the (1) DISTANCE TO CBD in 2001 and (2) DISTANCE TO THE NEAREST SUB-CENTRE<sup>100</sup> in 2001 for each municipality of the metropolitan area<sup>101</sup>. In addition, in the case of (2) it also has taken into account the distance to the nearest (21) LARGE SUB-CENTRE in 2001 and to the nearest (22) EMERGING SUB-CENTRE in 2001 in order to give a more in-depth analysis related to the urban spatial structure effects<sup>102</sup>. Hence, from a detailed point of view, because of the municipality of Barcelona (CBD) shows a diversified economic structure and, at the same time, a high degree of specialization in some economic sectors, its distance might capture urban spatial structure (metropolitan) urbanization economies, as well as urban spatial structure (metropolitan) localization economies. In the case of sub-centres, all subcentres (large and emerging) as it shown in (Figures 2a, 2b and 2c), resemble small CBDs and they might be related to both urban spatial structure (metropolitan) urbanization and localization economies. On the other side, by taking into account the characterization of sub-centres that (Masip, 2012a) has proposed: large-consolidated subcentres (places to work and live) and emerging ones (places to work), then emerging subcentres are smaller and more specialized and, as a result they might be more related to (urban spatial structure) localization economies with a metropolitan scope (but less than total sub-centres and less than large sub-centres). To

<sup>100</sup> As we see in following Section 4.4, in the case of sub-centres we use an inverted distance. Working with a direct distance for the case of the CBD (Barcelona) and an inverted distance for the case of the sub-centres implies that the spatial influence of the CBD is greater than that of the sub-centres. This assumption is common in most empirical studies (McDonald and Prather, 1994).

<sup>101</sup> These distances are in kilometers and they are computed by using a geographical information system (GIS) that compute the distance by road (not between centroid of each spatial unit) between each municipality to the central city of Barcelona (CBD) and to the nearest sub-centre which are identified in (Masip, 2012a).

<sup>102</sup> As we mentioned previously, the independent variables are measured at the beginning of the period, due to we try to take into account the existence of dynamic agglomeration economies, so we have to use lagged variables in order to mitigate the direct simultaneity between the dependent and independent variables. In order words, it is likely that there is endogeneity of spatial urban structure regressors what it may entail a recursive causality between urban structure and per capita income as well as per capita income growth: the configuration of households and economic activities located in a metropolitan region (urban structure) is driven by the economic performance of the metropolitan region itself and so, wages and/or incomes affects urban spatial structure, while in our study we try to examine the inverse relationship: how urban structure affects incomes.

test which type of sub-centres (and their related agglomeration economies) are more important, we estimate in the following Section 4.4. three specifications, one considering total sub-centres, and other two taking into account large and emerging ones respectively.

As a result, we expected that if per capita income and per capita income growth decreases with distance from centres (CBD and sub-centres: all, large and emerging), then the proximity to these centres matters, and consequently urban spatial structure also matters. However, according to the literature, the influence of proximity to the urbanization and localization economies that emerge from the central city (CBD) on income and its growth is still unclear. On the one hand, the study carried out by (Glaeser, 2000:135-136) show that the distance to the CBD is negatively associated with median income in 1990 and its growth between the period 1980 and 1990 in the metropolitan areas of Boston, Chicago, New York and Philadelphia: *“four all four of these metropolitan areas this relationship is strongly negative. Richer people live close to the CBD. This relationship levels off and then disappears farther away from the CBD”* and *“there is a significant positive relationship between income growth and proximity to the CBD. This relationship is strongest in New York City and Chicago in the 1980s”*. On the other hand, the research conducted by (Glaeser et al., 2008:17) reaches on the opposite conclusion: only in the case of old cities or subway cities the relationship between proximity to the central city (CBD) and incomes is defined by a U-shaped pattern: *“in subway cities, incomes first decline with respect to distance from CBD and then income increases as the distance to the CBD increases”* and then, in general and also in the case of newer cities (i.e. Los Angeles, Atlanta, and Phoenix) the distance to the central city is positively associated with incomes: *“in contrast, for non-subway cities and newer cities, income rise with distance from the CBD for tracts”* and *“more than 19 percent of people in American central cities are poor, in suburbs, just 7,5 percent of people live in poverty”*. However, as (Brueckner et al., 1999:105) has suggested, the concentration or poverty in central cities are strongly related to the presence of amenities at the time that its study points out that it seems that in Europe a different pattern as regards amenities in central cities is consolidated compared to the North-American one. In this sense, Brueckner’s work reveals that the relative location of different income groups depends on the spatial pattern of exogenous amenities in a city: *“when the center has a strong advantage over the suburbs in exogenous amenities, the rich are likely to live at central locations and when the center’s amenities advantage is weak or negative, the rich are likely to live in suburbs”* at the time that there is a clear different between the location pattern of amenities in U.S. cities and European cities: *“The Parisian pattern is also repeated in other European cities outside France as noted by Hohenberg and Less’ monograph on European urban history; they state that income rose with distance to the city center in America, whereas they typically fell in Europe”* and *“turning to historical amenities, Europe’s longer history provides an obvious reason why its central cities contain more buildings and monuments of historical significance than do their U.S. counterparts. Many European cities were major metropolises at a time when much of U.S. had not even been settled, and the legacy of urban development from this distant past provides an atmosphere in European city centers that appears to be highly valued by the residents”* (Brueckner et al., 1999:103).

In this sense, as our study case is the Barcelona Metropolitan Region, we suppose that as a European Metropolitan Region that it is, it follows the pattern described by (Brueckner et al., 1999) and consequently, the main cities (CBD and sub-centres) not only play the role of a city as a center of consumption but also, they hold the majority of natural, historic and modern-public amenities within the metropolitan area as well as the demand for new ones. Hence, we hypothesize that: (1) firstly, as we move away of the central city of Barcelona (CBD) and the sub-centres, the lower is the per capita income and its growth and (2) secondly, that CBD

present a higher significant influence on per capita income and per capita income growth compared to sub-centres due to its relevant degree of urbanization and localization economies as well as the more prominent presence of urban amenities at the same time because of the same reasons, large sub-centre should be more influential than the emerging ones. Next to this, by following (Rosenthal and Strange, 2004) which analyze in-depth the geographical/spatial scope of agglomeration economies, the third determinant that we consider in our study is related to the impact of local agglomeration economies generated in the same municipality. In this sense, it takes into account the effects of urbanization economies (and its externalities) through using (3) POPULATION DENSITY which is measured as the ratio between inhabitants that each municipality has and the built-up area<sup>103</sup> in square kilometers that it covers compared to other studies in the literature that use the gross population density (inhabitants/administrative area in km<sup>2</sup>). In addition, this indicator of urbanization economies at local scale can also be seen as an indicator of urban compactness. The literature has suggested that larger cities are expected to have high per capita income and predict its growth as well, through taking advantages of labour pooling and proximity and availability of intermediate goods and services for example (Lee and Prescott, 1974; Sveikauskas, 1975 –in 11 out of 14 industries-; Carlino, 1985; Carlino and Voith, 1995; Harris and Ioannides, 2000; Glaeser and Maré, 2001; Glaeser et al., 2001; Wheeler, 2001; Glaeser and Saiz, 2003; Glaeser and Shapiro, 2003 –taking into account the whole economy-; Glaeser and Kohlhase, 2004; Kim, 2006; Rice et al., 2006; Yankow, 2006; Di Addario and Patacchini, 2008; Glaeser et al., 2009; Goetz et al., 2010 and; Glaeser and Resseger, 2010). However, some studies have reached on the conclusion that urbanization economies by means of population density are negatively associated with per capita income and its subsequent growth (Glaeser et al., 1995; Glaeser and Shapiro, 2003 –considering manufacturing and adjusted wages-; Wheeler, 2004; Wheeler, 2008; Glaeser et al., 2012 and; Lee et al., 2013). The explanation that the literature has given regarding to this point is that after achieving a certain threshold size, this may also entail an increment of the congestions costs and land rents, so a reduction of the agglomeration benefits effects. As a result, we hypothesize that population density as a proxy of market size is positively associated with per capita income and its growth, although we are aware of that the role of density as proxy of urbanization economies in the literature has played sometimes divergence roles.

Finally, the last variable of the spatial urban structure that we have taken into account is (4) LAND USE BALANCE (diversity of land-use), so the functional diversification of the territory suggested by a wide variety of studies in the literature (Frank and Pivo, 1994, Cervero, 1996, 2002; Cervero and Kockelman, 1997 and; Cervero and Murakami, 2010) as regards urban structure and commuting. Although, functional diversification by means of land use diversity has been widely used in the literature in order to examine its influence on commuting distance and time, it may also play an important role related to per capita income and its growth because of functional diversification not only favours the proximity between places of living and working but also contribute to a higher presence of urban amenities and consumption in cities, (if a city presents a high land use diversity, it is more likely that

<sup>103</sup> To calculate the total built up area (in km<sup>2</sup>) for each municipality in the metropolitan area we use the data from Corine Land Cover considering the following artificial land uses: (1) full consideration of the land uses: continuous urban fabric (11100), discontinuous urban fabric (11210), discontinuous green urban areas (11220), industrial areas (12110), commercial and service areas (12110), port areas (12300), green urban areas (14100), courses field areas (14210) and rest of sport and leisure facilities (14220), (2) not taking into account the road and highway networks and associated land (12210), railroad networks (12220), mineral extraction sites (13100) and dump sites (13200) and finally, (3) not completely counting the artificial surface for: airports (12400) and construction sites (13300). In addition, it is worth mentioning that as regards the construction sites, we have deducted the areas which are roads, highway and railroad networks from the total area of the construction sites.



different kinds of business and shops, so also urban functions could emerge) and consequently may foster high per capita income and its growth. Therefore, we hypothesize that thanks to a higher functional diversification based on a diversity of land-use in a given municipality, the higher the per capita income and its subsequent growth. This dimension of the functional diversification of the territory has been approximated as follows: the diversity of land-use has calculated borrowing from what (Frank and Pivo, 1994:48) has proposed, so by using the entropy index to describe the evenness of the distribution of built square footage among land-use categories. In our case, we construct seven different categories of land-use on the basis of Corine Land Cover current categories in 2000: urban centre and continuous residential urban fabric, discontinuous residential urban fabric, industrial and commercial and service areas, infrastructural areas, logistic areas, green urban areas and other areas. So, the entropy index of mix land-use is expressed as the following (equation 7) shows:

$$Land\ use\ balance_{i(entropy\ value)} = - \sum_{j=1}^n (LU_{ij} \cdot [Ln(LU_{ij})]) \quad (5)$$

Where (Land use balance<sub>i</sub>) is the land diversity of territory (i=municipality), (j) is each of the considered land use categories and (LU<sub>ij</sub>) is the probability to find (j) in the given municipality (i). The higher is the (Land use balance<sub>i</sub>) for a given municipality (i), the higher the land diversity of this given territory (i).

Beyond the major spatial factors, the second group of variables are based on a set sociodemographic factors, which have been included in the analysis in order to take into account non-spatial determinants that can play a role in shaping urban inequality. The inclusion of such determinants in the estimation however permits a better interpretation of the empirical results, avoid, or at least reduce, problems of under-specification of the model. The first sociodemographic variable is the (5) HUMAN CAPITAL-LABOUR RATIO in 2001, which following (Meijers and Burger, 2010) is measured as the ratio between knowledge workers<sup>104</sup> and localized jobs that are within a given municipality (i). According to the literature, a larger stock of human capital raises wages and income by exposing workers to more information and allowing them to learn and exchange ideas more quickly. Hence, the explanation is that worker earns higher wages in human capital intensive areas through the working of the human capital externalities which facilitate to reach on higher levels of learning, innovation, and entrepreneurship for example. In this sense, the urban theory suggests that if the tendency of skilled entrepreneurs to employ skilled labors is rising, we should expect an increasing correlation between are level skills and area level income, so incomes rising more quickly in more skilled cities. Consequently, we hypothesize that the presence of human capital is positively associated with per capita income and its growth, which is consistent with the following current studies of literature (Glaeser et al., 1995; Harris and Ioannides, 2000; Graham, 2000; Glaeser and Maré, 2001; Wheeler, 2001; Glaeser and Saiz, 2003; Glaeser and Shapiro, 2003; Glaeser and Kohlhase, 2004; Moretti, 2004; Wheeler, 2004; Berry and Glaeser, 2005; Shapiro, 2005; Rice et al., 2006; Wheeler, 2006; Yankow, 2006; Wheeler, 2008; Combes et al., 2008; Glaeser et al., 2009; Goetz et al., 2010; Glaeser and Resseger, 2010; Glaeser et al., 2012 and; Lee et al., 2013).

Next to this, the second sociodemographic variables considered in our study is (6) POPULATION ABOVE 64 YEARS in 2001, which is measured as the ratio between

<sup>104</sup> Data of occupation sectors at 1 level of disaggregation is provided by IDESCAT (Institut d'Estadística de Catalunya). The database provided is CCO-94 in which group 2 refers to knowledge occupations (workers).

population above 64 years over all population in a given municipality (i). This variable attempts to capture to a certain point the role of the age structure on per capita income and its subsequent growth. It is often suggested in the literature that experience predicts per capita income because of workers needs time to accumulating knowledge: learning, exchange ideas (Glaeser and Maré, 2001). In addition, some studies have also remarkably pointed out that to a certain threshold of experience (Wheeler, 2001; Moretti, 2004; Wheeler, 2006; Yankow, 2006 and; Di Addario and Patacchini, 2008) there are no more returns to wages and incomes (experience is negatively associated or not significantly correlated). In this sense, we hypothesize that municipalities with higher presence of population above 64 years are negatively associated with per capita income and its growth because of their workers have exceeded the threshold in which experience is positively associated with wages<sup>105</sup> (this point may be characterized as the point which workers could not significantly accumulated more knowledge in order to foster more innovation for example). However, the literature does not reach on a convergence point about the role that age structure plays to incomes: while the studies of (Combes et al., 2008 and; Melo and Graham, 2009) present a positively association –the latter study reach on the conclusion that considering the whole economy and in 10 out of 12 analyzed 2-digit industries, age of workers is positively related to real hourly wages-; the work carried out by (Wheeler, 2008) shows that: workers aged below 24 years are related to high neighbourhood incomes and workers aged between 24 and 64 years as well as foreign-born workers aged above 65 years do not exert a statistically significant effect on changes in within and in between neighbourhood income.

Lastly, the last explanatory determinant of the sociodemographic characteristics that we have taken into account is (7) PER CAPITA INCOME (Gini information) in 2001, so the initial conditions of the income inequality distribution suggested by a wide variety of studies in the literature (Barro and Sala-I-Martin, 1991; Wheeler, 2004 and; Berry and Glaeser, 2005) as regards incomes and convergence process. In this sense, these studies state that there are two notions of convergences process. The former implies that if cities with different levels of inequality converge to a common level, so there will be a negative association between initial inequality and the magnitude of its subsequent change. The latter entails if cities are converging to a common level of inequality, then the cross-sectional standard deviation of inequality levels should decrease over time. In our study, we attempt to examine the effect of the first notion of convergence process and consequently, we hypothesize that there is a negative correlation between initial per capita income and its growth, so the municipalities which their workers holds lower per capita income increases more significantly its per capita income compared to the workers of the richest municipalities over time (Glaeser et al., 1995; Glaeser and Saiz, 2003; Wheeler, 2004; Berry and Glaeser, 2005; Glaeser et al., 2009 and; Glaeser et al., 2012). However, some studies (Glaeser et al., 2009 –by considering U.S. Metropolitan Statistical Area Gini income- and; Lee et al., 2013) reveal a positive association between initial income and its subsequent growth, so contracting the convergence hypothesis. In this sense, the literature has suggested, for example in the work carried out by (Berry and Glaeser, 2005) that convergence has declined substantially over the last 30 years and the potential reason that this study gives is that initial high income, and high skill, places are increasingly attracting more skilled people. Consequently places with higher levels of human capital have attracted more skilled over that the last three decades, becoming one of the most

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<sup>105</sup> We also try another age structure variables in order to capture experience effects: 1) share of young workers <24 years, 2) share of experimented workers related to youth ones, which is measured as people aged between 40 and 64 years over people aged between 24 and 39 years. However, the results (not reported here) of the regression models including these variables reveal that: all these alternative age structure variables do not exert a statistically influence on per capita income and its subsequent growth.

responsible for the increment of inequality and social segregation in and across metropolitan areas. Hence, initial conditions of per capita income have been approximated following (Glaser et al., 2009) by measuring the Gini index of per capita income as follows:

$$PCI_{i(GINI)} = \sum_1^n 2 * (A - B) * C \quad (6)$$

Where, (A) is the accumulated sum of proportions as regards the distribution (A) from 1 to (n); (B) is the accumulated sum of proportions related to the distribution (B) between 1 and (n); (C) is the difference between the accumulated sum of proportions of the distribution (A) from 1 to (n) and the accumulated sum of proportions of the distribution (B) from 1 to (n-1). In our case, (n) is the number of municipalities within the Barcelona Metropolitan Region, the distribution (A) refers to the proportion of the municipalities equality distribution<sup>106</sup> and the distribution (B) is related to the proportion of per capita income in 2001. Hence, the Gini coefficient will be equal to 0 when the distribution is completely egalitarian and if the metropolitan total income accrues to only one municipality, leaving the rest with no income at all, then the Gini coefficient will be equal to 1. In addition, as we are focusing on municipality scale and there is no availability data of incomes in the Barcelona Metropolitan Region below municipality scale, we have to define the per capita income Gini information as follows:  $PCI_{i(GINI\ information)} = 2 * (A - B) * C$ , which is the contribution of each municipality to the total per capita income Gini index, in order to be able to include this explanatory variable in the regression models of per capita income and per capita income growth.

Finally, we include two more explanatory determinants. The former is (8) URBAN AMENITIES in 2001,

Hence we hypothesize that urban amenities are positively associated with per capita income and its growth because of the higher is the presence of amenities in a municipality, the higher is the attraction of new population, and consequently the consumption tends to increase. Another reason may be that richest workers tend to locate its residence in cities that hold a relevant presence of amenities (Brueckner et al., 1999). The latter variable is related to the geographical localization of municipalities within the Barcelona Metropolitan Region, and it is defined as (9) COAST MUNICIPALITIES and computed as 1, if the municipality is adjacent to the coast and as 0, otherwise. Thus, this variable captures the differences between municipalities that are in the center or in the coast of the metropolitan region. The use of territorial dummies allow for these differences, although is unclear about what is expected in terms of its influence on per capita income and its subsequent growth. However, studies in the literature has suggested that natural amenities related to geographical location enhance incomes, if they are associated with attracting high-skilled labour or high productivity firms.

<sup>106</sup> In the process of Gini index calculation, we ranked all the municipalities from lowest to highest per capita income (distribution B). The distribution (A) takes in this case, a value of 1 for each considered municipality in the Barcelona Metropolitan Region, being (n) the total of municipalities in the region. Hence, the proportion (share) of the distribution (A) for each municipality is 1/n, so a value of 0,0060975 for each considered municipality. Another alternative, of the Gini index calculation that is commonly suggested in the literature, is considering the cumulative share of population as a distribution (A) and the per capita income or another income indicator as a distribution (B). However, in our study, we do not consider this alternative because we try to construct an indicator that could capture a) initial per capita income to analyze convergence process over time, and b) initial inequality. Thus, our indicator tries to analyze if initial inequality defined by the spatial distribution of per capita income is able to predict incomes and its subsequent growth.

### 4.3. Data

The following (Table 3) defines the variables names along with descriptions, data sources and the computation that our study has used to determine the variables explained previously.

**Table 3. Variable descriptions and sources for the Barcelona Metropolitan Region**

Variable name	Variable description	Data Source and computation	Year
<b>URBAN STRUCTURE - BUILT ENVIRONMENT VARIABLES</b>			
Distance to CBD (Barcelona). Urbanization and localization economies. Effects of agglomeration economies at metropolitan scale	Distance by road in (km) from each municipality in the Barcelona Metropolitan Region to the Barcelona (CBD)	Network road graphs and matrix of distances between municipalities (in kilometres) were provided by the Department of Regional Policy and Public Works (DPTOP). Based on these maps by using a GIS software is computed the distances to the CBD	2001
Distance to the nearest Sub-centre* (inverse measure). Localization and urbanization economies. Effects of agglomeration economies at metropolitan scale	Distance by road in (km) from each municipality in the Barcelona Metropolitan Region to the nearest Sub-centre	Network road graphs and matrix of distances between municipalities (in kilometres) were provided by the Department of Regional Policy and Public Works (DPTOP). Based on these maps by using a GIS software is computed the distances to the nearest Sub-centre	2001
Population density (logarithm). Urbanization externalities. Effects of agglomeration economies at local scale	Ratio between inhabitants in each municipality divided by the built-up area (in square km) of this municipality	Population data comes from INE (Instituto Nacional de Estadística) and the built-up area is computed for each municipality from data provided by Corine Land Cover.	2001 and 2000
Land use balance (entropy value)	Land use diversity of a given municipality calculated as the Shannon form of Entropy.	Land use categories comes from the built-up area in square kilometres provided by Corine Land Cover. This built-up area for each municipality has been classified into 7 different land use categories	2000
<b>SOCIODEMOGRAPHIC CONTROL VARIABLES</b>			
Human capital-Labor ratio (logarithm). Knowledge externalities	Measured as the ratio between knowledge workers and jobs that are within municipality (i)	Employment data which comes from travel-to-work mobility and data of occupation sectors at 1 level of disaggregation are provided by IDESCAT (Institut d'Estadística de Catalunya). The database provided is CCO-94 which refers to worker occupations, and group 2 is the knowledge workers	2001
Population above 64 years (percentage)	Ratio between population above 64 years over all population in municipality (i)	Population data comes from INE (Instituto Nacional de Estadística)	2001
Per capita income (Gini information)	Measured as the Gini index. This variable captures the Gini information of per capita income for each municipality (i) because of the lack of available data of per capita income under municipality scale	Per capita income data comes from IDESCAT (Institut d'Estadística de Catalunya). The databases provided are RFDB (Renta Familiar Disponible Bruta) and EES (Estadística d'Estructura Salarial)	2001 and 2002
<b>URBAN AMENITIES CONTROL VARIABLES</b>			
Urban amenities			2001
<b>GEOGRAPHICAL CONTROL VARIABLES</b>			
Coast Municipalities	1 if municipality is adjacent to coast, otherwise 0	GIS database provided by Department of Regional Policy and Public Works (DPTOP)	2001

Source: Own Elaboration. Note: \*Distance to the nearest all, large and emerging sub-centres

#### 4.4. Empirical analysis

In order to test these hypotheses, spatial econometric models have been carried out using the above-mentioned 164 municipalities that are within the Barcelona Metropolitan Region as unit of analysis. All the dependent variables have been computed as explained in Section 4.1 (equation 3 and 4) and as regards independent variables is used the measurements and descriptions presented in the previous Sections 4.2 and 4.3. In this sense, as we mentioned previously in the estimation of the econometric models we have to solve the endogeneity problem as regards the estimation of per capita income and its subsequent growth, due to we are taking into account in our study, the dynamic agglomeration economies. To do so, we use lagged variables (independent variables are measured at the beginning of the analyzed period) in order to mitigate the direct simultaneity between the dependent and independent variables. In addition, another problem that has to be solved is that, our data may have a location component, so according to the literature of spatial econometric techniques there are two problems -namely, (1) spatial dependence between the observations and (2) spatial heterogeneity. Spatial dependence between adjacent municipalities will have similar patterns of intermunicipality commuting. As a consequence, ordinary least squares (OLS) estimation is likely to be blighted by spatial correlation, which can take two forms- spatial lag and spatial error. The former is associated with the dependent variable being correlated with its nearby observations and ignoring this form of spatial correlation leads to inconsistent, biased estimators, so the inference of significance from OLS can be incorrect. The latter form of spatial correlation entails the correlation of errors with those of nearby observations, but ignoring this form of autocorrelation does not affect the consistency of estimators, only their efficiency. In our work, to deal with spatial dependence and spatial heterogeneity three types of regression models have been estimated: ordinary least squares (OLS), spatial lag model (SLM) and finally spatial error model (SEM). Hence, the basic forms of these three types of regressions models can be written as follows (equations 7, 8 and 9 respectively):

$$\gamma = X\beta + \varepsilon \quad (7)$$

$$\gamma = \rho W\gamma + X\beta + \varepsilon \quad (8)$$

$$\gamma = X\beta + \varepsilon_w \quad (9.1)$$

$$\text{and, } \varepsilon_w = \lambda W\varepsilon + \xi \quad (9.2)$$

Where (X) is a matrix of observations on the explanatory variables, ( $\varepsilon$ ) is the vector of error terms, ( $W\gamma$ ) is the spatially lagged predictor, ( $\rho$ ) is the spatial coefficient of the SLM, ( $\varepsilon_w$ ) is the vector of error terms, spatially weighted using the weights matrix (W), ( $\lambda$ ) is the spatial error coefficient of the SEM and finally, ( $\xi$ ) is a vector of uncorrelated error terms. As regards to the spatial lag model (SLM), (n) is the number of municipalities and (W) a spatial weighting matrix of dimension (n x n, in our case 164 x 164) whose elements assign the neighbours to each municipality. The weights matrix used in this study is characterized as  $W = \{w_{ij}\}$ , such that  $0 < w_{ij} \leq 1 \forall i \neq j$ , if (i) and (j) are neighbours, otherwise  $w_{ij} = 0$ , and in which  $w_{ii} = 0$ . In the weighted matrix, neighbours are defined as those municipalities that share a common border (administrative border) by using rook-standardized and queen-standardized weights as a spatial matrix of contiguity<sup>107</sup> and the hypothesis of spatial

<sup>107</sup> Compared to these weights to define the spatial matrix of contiguity, there are other forms: for example, by using distance-standardized weights. However, in our work we assess the performance of the rook-standardized and queen-standardized weights.

correlation is related to the parameter ( $\rho$ ), where  $H_0: \rho = 0$  (if there is no spatial dependence, and  $\gamma$  does not depend on neighbouring  $\gamma$  values,  $\rho=0$ ) is tested against the alternative,  $H_1: \rho \neq 0$ . If  $H_0$  is rejected, two possibilities arise. A positive and significant parameter estimate of ( $\rho$ ) indicates a positive correlation between i.e. per capita income growth rate in neighbouring municipalities (in this example the employment growth rate is the dependent variable). That is, high per capita income growth rate tend to ‘spillover’ and have a positive effect on per capita income growth rates in neighbouring municipalities. However, this effect could also be negative, which indicates that conditional to the other explanatory variables of the spatial lag model, the per capita income growth within one municipality tend to be at its neighbour’s expense (is taken the same example as previously). Then, as regards to the spatial error model, the dependence between municipalities works through the error process as the error from different regions may display spatial covariance. In technical terms, the difference between the spatial lag model and the spatial error model relate to the parameter ( $\rho$ ) and the error term ( $\varepsilon$ ) as we could observe by comparing the previous (equations 8 to 9.1 and 9.2). In the spatial error model (SEM),  $\rho \equiv 0$  and  $\varepsilon = \lambda W\varepsilon + \xi$ , or rearranging:  $\varepsilon = (I - \lambda W)^{-1}\xi$ , where ( $\lambda$ ) is a scalar spatial error coefficient,  $\xi \sim N(0, \sigma^2 I)$  and the original error terms has the non-spherical covariance matrix  $E[\varepsilon\varepsilon'] = (I - \lambda W)^{-1}\sigma^2 I(I - \lambda W)^{-1}$ . If the spatial error model is the right specification, the interpretation of the model is that a random shock will not only affect the region where it is introduced. Instead, it will spread to neighbouring municipalities and also throughout the system, so if  $\lambda=0$ , then there is no spatial correlation between the errors.

### Causes of urban inequality

To examine the determinants of the causes of urban inequality (per capita income) in 2008, the regression model that we estimate according to after considering the previous three different econometric models (equations 7, 8 and 9) is the functional equation which is estimated through using OLS techniques as follows<sup>108</sup>:

$$\begin{aligned} \ln(PCI_{i,08}) = & PCI_0 - \beta_1 d_{CBD_{01}} + \beta_2 d_{SUB_{01}}^{-1} + \beta_3 \ln DnPop_{01} + \beta_4 Land_{01} + \\ & \beta_5 \ln HC_{01} - \beta_6 Pop64_{01} + \beta_7 Amenities_{01} + \beta_8 Coast_{01} - \beta_9 PCI(Gini)_{01} + \varepsilon \end{aligned}$$

(equation 10)

Where ( $PCI_i$ ) is the per capita income in municipality (i) in 2008, ( $PCI_0$ ) is the intercept of the regression models, ( $d_{CBD}$ ) is the distance from municipality (i) to the CBD in 2001, ( $d_{SUB}^{-1}$ ) is the distance from municipality (i) to the nearest sub-centre in 2001, ( $DnPop$ ) is the net population density for a given municipality (i) in 2001, ( $Land$ ) is the diversity of land use for a given municipality (i) in 2001, ( $HC$ ) is the human capital labour ratio, measured as the ratio

<sup>108</sup> The (equation 10) is estimated though using OLS techniques because after testing for spatial dependence (results not reported here) by using spatial lag model (SLM) and spatial lag error (SEM) according to the previous (equations 8 and 9), the results of these regression models reveal that a) the parameter ( $\rho$ ) is not statistically significant, so there is no spatial dependence and ( $\gamma$ ) does not depend on neighbouring ( $\gamma$ ) values and b) the parameter ( $\lambda$ ) is also not statistically significant, so there is no spatial correlation between the error. Hence, as regards spatial lag models (SLM), the models show that according to the three different specifications defined in (Table 4), ( $\rho$ ) present the following probabilities (t-values): 1) 0,318; 0,847 and 0,818 by using queen-standardized weights respectively and, 2) 0,348; 0,7598 and 0,711 by using rook-standardized weights correspondingly. Next to this, referring with spatial error models (SEM), the models reveal that, ( $\lambda$ ) present the following probabilities (t-values): 1) 0,354; 0,447 and 0,836 by using queen-standardized weights respectively and, 2) 0,370; 0,500 and 0,743 by using rook-standardized weights correspondingly.

between knowledge workers and localised jobs that are within this given municipality (i) in 2001, (Pop64) is a demographic control variable calculated as the percentage of population above 64 years relative to the total population for each municipality (i) in 2001, (Amenities) in 2001, (Coast) is a geographical dummy variable that shows which municipalities are adjacent to the coast and finally, (PCI Gini) captures the initial conditions of urban inequality in order to examine the convergence process over time, measured as per capita income Gini information for each municipality (i). Then,  $\beta$  coefficients represent the gradients associated with each independent variable and the sign of these coefficients are expected to be according to the hypotheses explained in the previous Section 4.2 and ( $\epsilon$ ) is the vector of error terms. In addition, to examine in-depth the influence of urban structure on the causes of inequality, it is also studied the influence of sub-centre according to its characterization: large and emerging proposed by (Masip, 2012a) on per capita income. Starting from the previous (equation 10), the following (equation 11) and (equation 12) show the estimated regression models taking into account large and emerging sub-centre influence correspondingly:

$$\begin{aligned} \ln(PCI_{i,08}) = & PCI_0 - \beta_1 d_{CBD_{01}} + \beta_2 d_{SUB\,LARGE_{01}}^{-1} + \beta_3 \ln DnPop_{01} + \\ & \beta_4 Land_{01} + \beta_5 \ln HC_{01} - \beta_6 Pop64_{01} + \beta_7 Amenities_{01} + \beta_8 Coast_{01} - \\ & \beta_9 PCI(Gini)_{01} + \epsilon \end{aligned} \quad (\text{equation 11})$$

$$\begin{aligned} \ln(PCI_{i,08}) = & PCI_0 - \beta_1 d_{CBD_{01}} + \beta_2 d_{SUB\,EMERGING_{01}}^{-1} + \beta_3 \ln DnPop_{01} + \\ & \beta_4 Land_{01} + \beta_5 \ln HC_{01} - \beta_6 Pop64_{01} + \beta_7 Amenities_{01} + \beta_8 Coast_{01} - \\ & \beta_9 PCI(Gini)_{01} + \epsilon \end{aligned} \quad (\text{equation 12})$$

After these three regression models have been estimated using ordinary least squares (OLS), by considering sub-centres' influence according its characterization: all sub-centres, large sub-centres and emerging sub-centres, the results reported here will only consider the models estimated as regards all sub-centres. In this sense, the results of (OLS) regression models as regards the influence of large and emerging sub-centres on the causes of urban inequality by means of per capita income in 2008 are summarized in the Appendix (Table A1-A2). Hence, the following (Table 4) reveals the results of what are the determinants of per capita income in 2008 by taking into account the influence of all sub-centres. At first glance, the results highlight that urban structure exerts a significant influence on predicts per capita income in 2008. This influence is positively associated with per capita income level in 2008 in the way that the lower the agglomeration economies that emerged at local and metropolitan scale in the past, in 2001; the lower per capita income of the employed population in 2008. In this sense, the independent variables related to urban structure and the effects of agglomeration economies at metropolitan and local scale (column 1) are all statistically significant and they have a considerably explanatory power of per capita income in 2008, the  $R^2$  of the regression model is 36,6%. In addition, all these variables have the expected sign and the hypothesis explained in Section 4.2 are corroborated, centres defined by means of CBD and sub-centres are virtuous to enhance per capita income in 2008 and urban compactness measured as net population density for a proxy of urbanization economies and agglomeration economies with effects at local scale as well.

**Table 4. Spatial determinants of the causes of urban inequality (2008). Regression models estimated by Ordinary Least Squares (OLS): all sub-centres**

Dependent Variable	Y = Ln Per capita income (2008)		
Independent Variables	OLS Model (1)	OLS Model (2)	OLS Model (3)
Constant	3,31752*	10,29713***	5,36109***
	(t-value)	(1,68170)	(5,01028)
	(probability)	0,09457	0,00000
Distance to Barcelona - CBD 2001	-0,10803***	-0,09136***	-0,05447***
	(t-value)	(-4,55770)	(-3,33659)
	(probability)	0,00001	0,00106
Distance to nearest Subcentre 2001	3,50902**	3,20876**	2,60429***
	(t-value)	(2,06169)	(2,21286)
	(probability)	0,04085	0,02836
Population Density 2001 (Ln)	0,68030***	0,33048*	0,17569
	(t-value)	(3,56335)	(1,92044)
	(probability)	0,00048	0,05653
Land use balance 2001		5,73738***	1,31917
	(t-value)	(4,52732)	(1,52675)
	(probability)	0,00001	0,12887
Human Capital-Labor ratio 2001 (Ln)		1,59578***	0,72913**
	(t-value)	(3,12586)	2,19501
	(probability)	0,00211	0,02965
Population above 64 years 2001 (%)		-22,58988***	-11,29177**
	(t-value)	(-2,97639)	(-2,29458)
	(probability)	0,00338	0,02310
Urban Amenities <sup>A</sup> 2001		0,00854***	0,0031**
	(t-value)	(4,38045)	(2,46108)
	(probability)	0,00002	0,01495
Coast Municipalities 2001		1,77135**	1,00741**
	(t-value)	(2,38626)	(2,10608)
	(probability)	0,01822	0,03681
Per capita income 2001 (Gini)			4568,525***
	(t-value)		(14,95294)
	(probability)		0,00000
Number of observations	164	164	164
R-squared	0,36617	0,57887	0,82824
Adjusted R-squared	0,35429	0,55714	0,81820
F-statistic	30,8121	26,633	82,5143
F (sig)	0,00000	0,00000	0,00000
Log likelihood	-447,009	-413,484	-339,942

\*\*\*, \*\*, \* variables significant at 99 per cent, 95 per cent and 90 per cent respectively

Source: Own Elaboration

Consequently, related to the effect of agglomeration economies at metropolitan scale on the basis of urban spatial structure, the statistically negative sign of ( $\beta_1 = -0,10803^{***}$ ) reveals that



as we move away from the central city of Barcelona (CBD), the per capita income in 2008 decreases with the distance due to the urbanization and localization economies that have emerged from the CBD in 2001 and act on a metropolitan scale are less intensive. Then, the same is true for sub-centres but in a less extent due to is taken the assumption that their urbanization and localization economies exert a less relevant influence compared to CBD (inverse distance), so the statistically positive sign of ( $\beta_2=3,50902^{**}$ ) shows that as we move away from the nearest sub-centre, the lower is also the per capita income in 2008; so the empirical results confirm the assumption that per capita income in 2008 also depends on proximity to the sub-centres in 2001 and hence to the access to their past localization and urbanization economies. These results coincide with a) the evidence that (Masip, 2012b) reaches on as regards subcentre's influence and labour productivity, b) the virtuous association that (Masip, 2012c) points out between subcentre's influence and social and environmental costs due to commuting in order to reduce these aforementioned costs and, c) the evidence that (García-López and Muñiz, 2012) reveal related to the relationship between subcentre's effect and employment growth. In addition, the results are consistent with the findings suggested by (Glaeser, 2000) as well as with the amenity theory location in European metropolitan cities proposed by (Brueckner et al., 1999): these results as regards the relationship between CBD's and subcentres' effect on per capita income level may suggest that in the case of the Barcelona Metropolitan Region, amenities tends to be concentrated on the main centres of the metropolitan area (CBD and sub-centres).

Next to this, it is interesting to note that CBD's influence on per capita income as we expected is slightly more relevant than sub-centre one: the proximity of urbanization and localization economies that emerge from CBD in 2001 effect more prominently in per capita income in 2008 than the localization and urbanization economies that arise from sub-centres due to CBD's t-value as (column 1) shows in absolute terms is quite higher (-4,5570) compared to sub-centres' one (2,06169). In this sense, the (Tables A1-A2) in the Appendix, examine in-depth and give more details about the relationship between sub-centres and per capita income by considering its influence according to the nature of its formation: large and emerging. By analyzing, the results of the regression models presented in the (Table A1) and (Table A2) and making a comparison with the results that we have just explained by taking into account all sub-centres, as (Table 4) has shown, we can conclude that: a) as we expected, large sub-centres exert considerably higher influence to foster per capita income compared to emerging ones due to their urbanization and localization economies are more prominent, this is shown by observing the statistically significant and positive sign of the coefficient ( $\beta_2=3,26125^{***}$ ) and t-value of (0,5117) for large sub-centres and the positive but not statistically significant of the coefficient ( $\beta_2=2,09052$ ) and t-value (0,19254) as regards emerging sub-centres and; b) this more efficient influence of large sub-centres compared to emerging ones to predict high per capita income in 2008 entail a quite higher  $R^2$  for urban spatial structure variables, 36,4% by considering large sub-centres in the regression model in comparison with 35,6% by taking into account emerging sub-centres. Such observations are related to what we pointed out previously: urbanization and localization economies are more prominent in large sub-centres than the emerging sub-centres ones. The explanation is closely linked to the nature of subcentre formation: large sub-centres according to (Masip, 2012a) have a strong local labour market and they are important economic poles within the metropolitan areas, so they are both places to live and work, in other words they are able to retain its resident employed population as well as attracting working from all the metropolitan area that it means that they have relevant both urbanization economies related to its capacity to retain its population and localization economies related to attract workers, while emerging sub-centres as (Masip, 2012a) points out they only have a functionally autonomous local labour market or able to

attract workers, so they only have prominent urbanization economies or localization ones but not both contrary to what large sub-centres have.

Secondly, in terms of impact of local agglomeration economies generated in the same municipality, the empirical evidence reveals that municipalities that are more compact foster higher per capita income. In other words, urbanization economies in 2001, which are a proxy of urban compactness and city size matters on per capita income 7 years after. The positive and statistically sign of ( $\beta_3=0,68030^{***}$ ) entails that the higher was the population density of a municipality in 2001, the higher is the per capita income for this municipality in 2008. As a result, this confirms what we expected, as in Section 4.2 has pointed out, and what other studies in the literature (Carlino, 1985; Carlino and Voith, 1995; Harris and Ioannides, 2000; Glaeser and Maré, 2001; Glaeser et al., 2001; Wheeler, 2001; Glaeser and Saiz, 2003; Glaeser and Kohlhase, 2004; Kim, 2006; Rice et al., 2006; Yankow, 2006; Di Addario and Patacchini, 2008; Glaeser et al., 2009; Goetz et al., 2010 and; Glaeser and Resseger, 2010) have found previously in terms of urbanization economies externalities by using population density as its proxy and per capita income.

Thirdly, next to considering only the impact of metropolitan and local agglomeration economies on per capita income in 2008, when other explanatory variable are included as regards built environment and sociodemographic characteristics of municipalities (column 2), the regression model reveals that the previous urban structure variables are still statistically significant and they present the expected sign, so agglomeration economies that has emerged from centres (CBD and sub-centres) and from urban compactness in 2001 are still behind the prediction of high per capita income levels in 2008. However, what is also true now is that by including other explanatory determinants their effects are slightly less relevant: i.e. when is not considered built environment and sociodemographic determinants the ( $\beta$ ) coefficient and t-value of distance to the CBD are ( $\beta_1=-0,10803^{***}$ ) and (-4,55770) respectively, compared to when are included in the regression model these other explanatory factors, ( $\beta_1=-0,09136^{***}$ ) and (-3,33659) correspondingly. In this sense, it is worth mentioning that this dynamic of effects attenuation as regards urban structure variables, when other variables are taken into account is more accused in the cases of sub-centres' effect and urban compactness rather than in the case of CBD's influence: in the case of sub-centres, the ( $\beta$ ) coefficient decreases approximately 0,3 points to ( $\beta_2=3,20876^{**}$ ), although its effect has become more significant because of an increment of its t-value around 0,2 points, up to (2,21286); and in the case of population density, both values decreases; the ( $\beta$ ) coefficient around 0,35 points, specifically to ( $\beta_3=0,33048^*$ ) and the t-value decreases to (1,92044) entailing that population density is statistically significant at 94,35% level of confidence.

Hence, as regards the another built environment variable included at municipality scale, which is land use balance, the results show that has the expected sign and its effect statistically significant above 99% level of confidence with a coefficient of ( $\beta_4=5,73738^{***}$ ). Consequently, functional diversification by means of diversity of land use fosters future per capita income level. This corroborates the previous hypothesis presented in Section 4.2 at the time that is also consistent with the studies in the literature that claim that functional diversification plays an important role in the commuting distances and time. Thus, because of the results of the regression model, we can extend now the role of diversity land beyond commuting patterns by affirming that proximity between places of living and working and its contribution to a higher presence of consumption in cities is positively associated with high per capita income. Then, as regards to sociodemographic control variables, the results shows

that human capital externalities predicts per capita income in 2008, while non-working population or population in the last stage of its working life cycle (population above 64 years) in 2001 is negatively associated with per capita income 7 years after. Therefore, the statistically significant coefficient of ( $\beta_5=1,59578^{***}$ ) points out that human capital externalities (dynamic effect) is positively associated with per capita income in 2008. This finding, corroborates the hypothesis explained in the previous Section 4.2 on the basis of worker earns higher wages in human capital intensive areas through the working of the human capital externalities which facilitate to reach on higher levels of learning, innovation, and entrepreneurship for example. In addition, it is consistent with the studies of (Glaeser et al., 1995, 2009, 2012; Harris and Ioannides, 2000; Glaeser and Maré, 2001; Glaeser and Saiz, 2003; Glaeser and Shapiro, 2003; Glaeser and Kohlhase, 2004; Moretti, 2004; Wheeler, 2004, 2006, 2008; Rice et al., 2006; Yankow, 2006; Combes et al., 2008; Goetz et al., 2010; Glaeser and Resseger, 2010 and; Lee et al., 2013) and it contradicts the findings of the few works carried out by (Glaeser and Shapiro, 2003 –by considering manufacture wages-; Wheeler, 2004 –as regards change 90<sup>th</sup>-10<sup>th</sup> weekly wage differential-; Fingleton, 2006 and; Glaeser and Resseger, 2010 –as regards education between 0 and 11 years-) which reach on a negative or not significant correlation between human capital and incomes. Next to this, the statistically significant coefficient of ( $\beta_6=-22,58988^{**}$ ) show that age structure exerts a statistically significant influence on per capita income; specifically the share of population over 64 years in cities is negatively associated with per capita income in 2008. Consequently, this finding suggests that there is a certain point of knowledge experience in which accumulating more knowledge, learning and exchange ideas do not foster higher per capita income. This is consistent with what we expected, corroborating the hypothesis explained in Section 4.2 and with the current works of (Wheeler, 2001; Moretti, 2004; Wheeler, 2006; Yankow, 2006 and; Di Addario and Patacchini, 2008), although it is opposed to the results obtained in the studies of (Combes et al., 2008; Wheeler, 2008 and; Melo and Graham, 2009).

Beyond considering sociodemographic, we also included in this second specification of the regression model as regards the causes of per capita income in 2008 (column 2), two more control variables related to the presence of urban amenities in municipalities and to its geographical location. In this sense, as regards the former control variable, the model shows a positively and statistically significant of the coefficient ( $\beta_8=0,00854^{***}$ ). Thus, the presence of urban amenities in municipalities in 2001 is able to foster high per capita income in 2008. This is consistent with our hypothesis explained in Section 4.2 and with the research conducted by (Brueckner et al., 1999 and; Glaeser et al., 2001) at the time that it may contribute to explain more robustly because per capita income decreases as there is less proximity (and access) to the urbanization and localization economies of the central cities (CBD and sub-centres), which is the first main finding that we have reached on this work (see, the signs of the coefficients  $\beta_1$  and  $\beta_2$  of the previous Table 4). Related to the latter control variable, the model reveals that coast municipalities are positively statistically associated with per capita income ( $\beta_9=1,77135^{***}$ ). This is consistent with the literature in the sense that it is often suggested that places that hold some kind of natural (geographical) and/or weather advantages compared to others places, tend to enhance the benefits of agglomeration economies, so also per capita income.

Finally, we also considered the effect of initial per capita income as a cause of urban inequality in 2008, presented in (column 3) of (Table 4). Thus, the statistically significant and positive sign of ( $\beta_7=4568,525^{***}$ ) implies that the municipalities that hold the highest per capita income in 2001 foster the highest per capita income level 7 years after. This is consistent with (Glaeser et al., 2009 –by considering Gini income in 2006- and; Lee et al.,

2013 –across 533 U.S. municipalities in 21 counties of New Jersey State-). Consequently, this finding may entail that in the Barcelona Metropolitan Region, between 2001 and 2008, instead of occurring a convergence process as regards per capita income, there has been segregation and polarization process driven by the main centres (CBD and sub-centres) of the metropolitan area because of the regression model results (column 3) are still revealing that proximity to urbanization and localization economies that have emerged from CBD and sub-centres in 2001 foster high per capita income in 2008 (see, the statistically significant and expected sign of the coefficient  $\beta_1=-0,05447^{***}$  and  $\beta_2=2,60429^{***}$  respectively). However, we could confirm this hypothesis of convergence or divergence in the further analysis, when is examined in-depth, the consequences of urban inequality, so what determinants have driven the process of per capita income growth between 2001 and 2008.

### Consequences of urban inequality

To examine the determinants of the consequences of urban inequality (per capita income growth) between 2001 and 2008, the regression model that we estimate according to after considering the previous three different econometric models (equations 7, 8 and 9) is the functional equation which is estimated through using OLS techniques as follows<sup>109</sup>:

$$\ln \left( \frac{PCI_{i,08}}{PCI_{i,01}} \right) = \left( \frac{PCI_{08}}{PCI_{01}} \right)_0 - \beta_1 d_{CBD_{01}} + \beta_2 d_{SUB_{01}}^{-1} + \beta_3 \ln DnPop_{01} + \beta_4 Land_{01} + \beta_5 \ln HC_{01} - \beta_6 Pop64_{01} + \beta_7 Amenities_{01} + \beta_8 Coast_{01} - \beta_9 PCI(Gini)_{01} + \varepsilon$$

(equation 13)

Where  $(PCI_{08}/PCI_{01})$  is the per capita income growth in municipality (i) between 2001 and 2008,  $(PCI_{08}/PCI_{01})_0$  is the intercept of the regression models,  $(d_{CBD})$  is the distance from municipality (i) to the CBD in 2001,  $(d_{SUB}^{-1})$  is the distance from municipality (i) to the nearest sub-centre in 2001,  $(DnPop)$  is the net population density for a given municipality (i) in 2001,  $(Land)$  is the diversity of land use for a given municipality (i) in 2001,  $(HC)$  is the human capital labour ratio, measured as the ratio between knowledge workers and localised jobs that are within this given municipality (i) in 2001,  $(Pop64)$  is a demographic control variable calculated as the percentage of population above 64 years relative to the total population for each municipality (i) in 2001,  $(Amenities)$

(Coast) is a geographical dummy variable that shows which municipalities are adjacent to the coast and finally,  $(PCI Gini)$  captures the initial conditions of urban inequality in order to examine the convergence process over time, measured as per capita income Gini information for each municipality (i). Then,  $\beta$  coefficients represent the gradients associated with each independent variable and the sign of these coefficients are expected to be according to the hypotheses explained in the

<sup>109</sup> The (equation 13) is estimated though using OLS techniques because after testing for spatial dependence (results not reported here) by using spatial lag model (SLM) and spatial lag error (SEM) according to the previous (equations 8 and 9), the results of these regression models reveal that a) the parameter ( $\rho$ ) is not statistically significant, so there is no spatial dependence and ( $\gamma$ ) does not depend on neighbouring ( $\gamma$ ) values and b) the parameter ( $\lambda$ ) is also not statistically significant, so there is no spatial correlation between the error. Hence, for instance, as regards spatial lag models (SLM), the models show that according to the three different specifications defined in (Table 5), ( $\rho$ ) present the following probabilities (t-values): 1) 0,127; 0,349 and 0,173 by using queen-standardized weights respectively and, 2) 0,140; 0,385 and 0,210 by using rook-standardized weights correspondingly.

previous Section 4.2 and ( $\varepsilon$ ) is the vector of error terms. In addition, to examine in-depth the influence of urban structure on the causes of inequality, it is also studied the influence of sub-centre according to its characterization: large and emerging proposed by (Masip, 2012a) on per capita income. Starting from the previous (equation 13), the following (equation 14) and (equation 15) show the estimated regression models taking into account large and emerging sub-centre influence correspondingly:

$$\begin{aligned} \ln \left( \frac{PCI_{i,08}}{PCI_{i,01}} \right) = & \left( \frac{PCI_{08}}{PCI_{01}} \right)_0 - \beta_1 d_{CBD_{01}} + \beta_2 d_{SUB\ LARGE_{01}}^{-1} + \beta_3 \ln DnPop_{01} + \\ & \beta_4 Land_{01} + \beta_5 \ln HC_{01} - \beta_6 Pop64_{01} + \beta_7 Amenities_{01} + \beta_8 Coast_{01} - \\ & \beta_9 PCI(Gini)_{01} + \varepsilon \end{aligned} \quad (\text{equation 14})$$

$$\begin{aligned} \ln \left( \frac{PCI_{i,08}}{PCI_{i,01}} \right) = & \left( \frac{PCI_{08}}{PCI_{01}} \right)_0 - \beta_1 d_{CBD_{01}} + \beta_2 d_{SUB\ EMERGING_{01}}^{-1} + \beta_3 \ln DnPop_{01} + \\ & \beta_4 Land_{01} + \beta_5 \ln HC_{01} - \beta_6 Pop64_{01} + \beta_7 Amenities_{01} + \beta_8 Coast_{01} - \\ & \beta_9 PCI(Gini)_{01} + \varepsilon \end{aligned} \quad (\text{equation 15})$$

As previously, after these three regression models have been estimated through using ordinary least squares (OLS), by considering sub-centres' effects according to its characterization: all sub-centres, large sub-centres and emerging sub-centres, the results reported here will only consider the models estimated as regards all sub-centres. In this sense, the results of (OLS) regression models as regards the influence of large and emerging sub-centres on the consequences of urban inequality by means of per capita income growth between 2001 and 2008 are summarized in the Appendix (Table B1-B2). Hence, the next (Table, 5) points out the results of what are the determinants that predict per capita income growth from 2001 to 2008 by considering the influence of all sub-centres. At first glance, the results reveal that urban spatial structure exerts a significant influence on foster per capita income growth. This influence is positively associated with per capita income growth, so the higher the agglomeration economies that have emerged at local and metropolitan scale in the past, that is in 2001, the higher per capita income growth of the employed population between 2001 and 2008. In this sense, the explanatory variables related to urban structure and the effects of agglomeration economies at metropolitan and local scale (column 1) are all statistically significant and they have a remarkable explanatory power of per capita income growth, the  $R^2$  of the regression model is 36,56%. In addition, all these variables have the expected sign and the hypothesis explained in Section 4.2 are confirmed, urban nodes that define the polycentric structure at intra-metropolitan scale, by means of CBD and sub-centres are virtuous to predict per capita income growth and urban compactness measured as net population density for a proxy of urbanization economies and agglomeration economies with effects at local scale as well. As a consequence, referring with the influence of agglomeration economies at metropolitan scale on the basis of urban spatial structure, the statistically and negative sign of ( $\beta_1=-0,00382^{***}$ ) reveals that as we move away (less proximity) from the central city of Barcelona (CBD), the per capita income growth between 2001 and 2008 decreases with the distance due to the urbanization and localization economies that have emerged from the CBD in 2001 and act on a metropolitan scale are less prominent. Then, the same is true for sub-centres but in a less extent due to is taken the assumption that their urbanization and localization economies exert a less relevant influence compared to CBD (note that the distance to the nearest sub-centre is included in the regression model as inverse magnitude).

**Table 5. Spatial determinants of the consequences of urban inequality (2001–2008). Regression models estimated by Ordinary Least Squares (OLS): all sub-centres**

Dependent Variable	Y = Ln p.c. income 2008 - Ln p.c. income 2001 ( Ln 2008 / 2001 )		
Independent Variables	OLS Model (1)	OLS Model (2)	OLS Model (3)
Constant	0,08976	0,34362***	0,17496***
	(t-value)	(1,23777)	(4,48374)
	(probability)	0,21761	0,00001
Distance to Barcelona - CBD 2001	-0,00382***	-0,00325***	-0,00199***
	(t-value)	(-4,38400)	(-3,18626)
	(probability)	0,00002	0,00174
Distance to nearest Subcentre 2001	0,12889**	0,10916**	0,08850**
	(t-value)	(2,06008)	(2,01881)
	(probability)	0,04101	0,04523
Population Density 2001 (Ln)	0,02818***	0,01484**	0,00955**
	(t-value)	(4,01538)	(2,31307)
	(probability)	0,00009	0,02203
Land use balance 2001		0,21257***	0,06160*
	(t-value)	(4,49818)	(1,72195)
	(probability)	0,00001	0,08708
Human Capital-Labor ratio 2001 (Ln)		0,06293***	0,03332**
	(t-value)	(3,30605)	(2,42294)
	(probability)	0,00117	0,01655
Population above 64 years 2001 (%)		-0,71175***	-0,32569
	(t-value)	(-2,51483)	(-1,59849)
	(probability)	0,01292	0,11198
Urban Amenities <sup>A</sup> 2001		0,00028***	0,00010*
	(t-value)	(-3,94517)	(-1,93820)
	(probability)	0,00012	0,05442
Coast Municipalities 2001		0,07456***	0,04845**
	(t-value)	(2,69360)	(2,44674)
	(probability)	0,00784	0,015540
Per capita income 2001 (Gini)			156,104***
	(t-value)		(12,34009)
	(probability)		0,00000
Number of observations	164	164	164
R-squared	0,37731	0,57428	0,78594
Adjusted R-squared	0,36564	0,55231	0,77343
F-statistic	32,3178	26,1371	62,8277
F (sig)	0,00000	0,00000	0,00000
Log likelihood	94,7337	125,916	182,294

\*\*\*, \*\*, \* variables significant at 99 per cent, 95 per cent and 90 per cent respectively

Source: Own Elaboration

Thus, the statistically positive sign of ( $\beta_2=0,12889^{**}$ ) shows that as we move away (less access) from the nearest sub-centre, the lower is also the per capita income growth between

2001 and 2008; so the empirical findings corroborated the hypothesis that per capita income growth also depends on proximity to the sub-centres in 2001 and hence to the access to their past localization and urbanization economies. These results are consistent with the findings suggested by (Glaeser, 2000) for the metropolitan areas of Boston, Chicago, New York, Philadelphia as regards growth in median income between 1980 and 1990 and also indicate that in the case of the Barcelona Metropolitan Region the urbanization and localization economies that emerge from the CBD and from the sub-centres have driven the subsequent growth of per capita income until 2008. Hence, the employed population that works in these main cities (CBD and sub-centres) of the metropolitan area and those that have better accessibility (proximity) to them, are the workers which have more experienced an increment of its per capita income between 2001 and 2008. However, it is worth mentioning that by comparing the coefficient ( $\beta_1$ ) and ( $\beta_2$ ) of (column 1) in the (Table 4) and (Table 5) respectively is clear that access to the urbanization and localization economies of CBD and sub-centres is more important (influential) in the case of per capita income rather than the case of per capita income growth: the value of the coefficients of distance to the CBD ( $\beta_1$ ) and distance to the nearest sub-centre ( $\beta_2$ ) are lower when is attempt to explain the consequences of urban inequality (Table 5). Next to this, the results are also in accordance with the amenity theory location in European metropolitan cities proposed by (Brueckner et al., 1999): the results as regards the relationship between CBD's and sub-centres' effect on per capita income growth may suggest that as we mentioned previously, amenities tend to be concentrated in them and that this concentration not only may be behind the prediction of per capita income but also it may foster per capita income growth as well.

In addition, it is interesting to note that CBD's explanatory capacity for per capita income growth as we expected is more important than sub-centre one: the proximity of urbanization and localization economies that arise from CBD in 2001 effect more prominently in per capita income subsequent growth until 2008 than the localization and urbanization economies that arise from sub-centres due to CBD's t-value as (column 1) presents in absolute terms quite higher (-4,38400) compared to sub-centres' one (2,06088). In this sense, the (Tables B1-B2) in the Appendix, examine in detail the relationship between sub-centres and per capita income growth by taking into account its influence according to the nature of its formation: large and emerging. By analyzing, the results of the regression models presented in the (Table B1) and (Table B2) and making a comparison with the results that we have just explained by considering all sub-centres, as (Table 5) has revealed, we can reach on the following conclusions: a) as we expected, large sub-centres exert considerably higher effects to predict per capita income growth compared to emerging ones due to their urbanization and localization economies are more prominent, this is shown by observing the statistically significant and positive sign of the coefficient ( $\beta_2=0,12228^{**}$ ) and t-value of (2,00501) for large sub-centres and the positive but not statistically significant of the coefficient ( $\beta_2=0,07169$ ) and t-value (0,22426) as regards emerging sub-centres and; b) this more efficient effect of large sub-centres compared to emerging ones to foster high per capita income growth between 2001 and 2008 entail a quite higher  $R^2$  for urban spatial structure variables, 36,47% by considering large sub-centres in the regression model in comparison with 35,48% by taking into account emerging sub-centres. As previously, when we have analyzed its influence on per capita income in 2008, such observations are related to what we pointed out in terms of that urbanization and localization economies are more relevant in large sub-centres than in the emerging ones due to its different nature of formation (Masip, 2012a).

Secondly, referring with the impact of local agglomeration economies generated in the same municipality, the empirical results show that municipalities that are more compact are

positively statistically associated with per capita income growth. This is to say that urbanization economies externalities in 2001, which are a proxy of urban compactness and city size matters on the subsequent growth of per capita income since 2001. Thus, the positive and statistically sign of ( $\beta_3=0,2818^{***}$ ) entails that the higher was the population density of a municipality in 2001, the higher is the per capita income growth for the employed population of this municipality until 2008. As a consequence, this also corroborates what we expected, as has explained in Section 4.2 and what other studies in the literature (Carlino, 1985; Harris and Ioannides, 2000; Glaeser and Saiz, 2003; Glaeser and Shapiro, 2003; Kim 2006; Rice et al., 2006; Di Addario and Patacchini, 2008; Glaeser et al., 2009 and; Goetz et al., 2010) have reached on previously in terms of urbanization economies by using population density as its proxy and the subsequent growth of per capita income.

Thirdly, next to taking into account only the effects of agglomeration economies at metropolitan and local in per capita income growth between 2001 and 2008, when other explanatory determinants are included as regards built environment and sociodemographic characteristics of municipalities, such as the second specification of the regression model shows (column 2), the results reveal that the previous urban structure variables are still statistically significant and they present the expected sign, so proximity to the urbanization and localization economies that have emerged from centres (CBD and sub-centres) and urbanization externalities that have arisen from urban compactness in 2001 are still driving the prediction of subsequent growth of per capita income since 2001. However, what is true again, as we have observed in per capita income in 2008 regression models (Table 4), is that by including other explanatory variables their effects are slightly less important: i.e. when is not considered built environment and sociodemographic determinants the ( $\beta$ ) coefficient and t-value of distance to the CBD are ( $\beta_1=-0,00382^{***}$ ) and (-4,38400) respectively, compared to when are included in the regression model these other explanatory factors, ( $\beta_1=-0,00325^{***}$ ) and (-3,18626) respectively. In this sense, note that these effects of attenuation related to urban structure determinants, when other determinants are considered is more accused and relevant in the cases of sub-centres' influence and urban compactness rather than in the case of CBD's effect: in the case of sub-centres, the ( $\beta$ ) coefficient and t-value decrease around 0,02 points and 0,05 points, so reaching the values of ( $\beta_2=0,10916^{**}$ ) and (2,01881) respectively; and in the case of population density, both values also decreases, but more prominently, the ( $\beta$ ) coefficient around 0,014 points, specifically to ( $\beta_3=0,01484^{**}$ ) and the t-value decreases to (2,31307) what implies a reduction of 1,70 points approximately entailing that population density is statistically significant at 97,79% level of confidence.

Consequently, related to determinant of land use balance (diversity of land), the results show that has the expect sign and its effect statistically significant above 99% level of confidence with a coefficient of ( $\beta_4=0,21257^{***}$ ). Thus, functional diversification by means of diversity of land use, not only predict the causes of urban inequality (per capita income level in 2008, see the previous Table 4) but also fosters its subsequent growth until 2008, so their consequences (per capita income growth between 2001 and 2008), so it contributes to define a metropolitan territory with more social segregation. As previously, when we have analyzed the causes of per capita income, this finding corroborates the previous hypothesis explained in Section 4.2 at the time that is also consistent with the studies in the literature that have suggested that functional diversification have an important influence on commuting patterns such as the works of (Frank and Pivo, 1994, Cervero, 1996, 2002; Cervero and Kockelman, 1997 and; Cervero and Murakami, 2010) among others. Then, in terms of sociodemographic control variables, the results reveal that human capital externalities foster per capita income growth between 2001 and 2008, while non-working population or population in the last stage

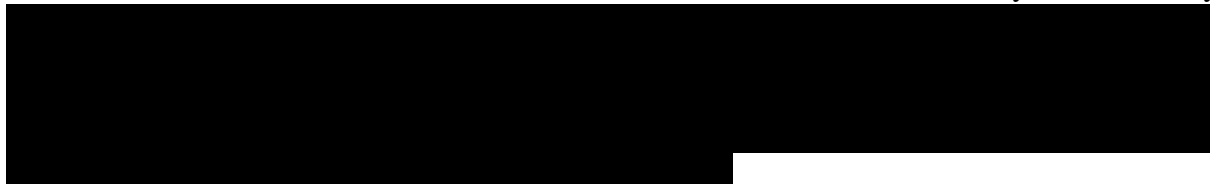


of its working life cycle (population above 64 years) in 2001 is negatively associated with the subsequent growth of per capita income since 2001. Hence, the statistically significant coefficient of ( $\beta_5=0,06293^{***}$ ) entail that human capital externalities is positively associated with the consequences of urban inequality, so with per capita income growth between 2001 and 2008. This finding, corroborates the hypothesis explained in the previous Section 4.2 at the time that supports the idea that behind the divergence process that we started to suspect when we found a positive and statistically sign of initial conditions of per capita income in 2008 (see, [Table 4](#)), instead of observing a convergence one in terms of per capita income suggested for example by the literature in the study of ([Barro and Sala-I-Martin, 1991](#)), there is the influence of a more polarized distribution across the space and cities of the human capital presence. Consequently, we can conclude now that human capital is clearly one of the determinants that drives this unfolding social segregation and polarization of per capita income in the Barcelona Metropolitan Region. This dynamic, is in-depth explained in the literature in the work carried out by ([Berry and Glaeser, 2005](#)), in which points out that there is a rising tendency in metropolitan areas of skilled entrepreneurs to employ skilled labors, so is expected that this increasing correlation between area level skills and area level income leads to incomes rising more quickly in more skilled cities. In addition, the result that the regression model reaches on as regards the effect of human capital on per capita income growth, presented in ([Table 5](#)), is consistent with the studies of ([Glaeser et al., 1995](#); [Glaeser and Saiz, 2003](#); [Glaeser and Shapiro, 2003](#); [Berry and Glaeser, 2005](#); [Shapiro, 2005](#); [Rice et al., 2006](#); [Wheeler, 2004, 2006, 2008](#); [Combes et al., 2008](#); [Glaeser et al., 2009](#); [Goetz et al., 2010](#); [Glaeser et al., 2012](#) and; [Lee et al., 2013](#)). Next to this, the statistically significant coefficient of ( $\beta_6=-0,71175^{***}$ ) imply that age structure also exerts a statistically significant influence on the consequences of urban inequality. Thus, the share of population over 64 years in cities is negatively associated with per capita income growth between 2001 and 2008. In this sense, as previously, regarding with per capita income in 2008 ([Table 4](#)), this result suggest that after a certain point of knowledge accumulation there is no positive returns to per capita income and its subsequent growth.

Apart from taking into account these sociodemographic variables, we also have included in this second specification of the regression model ([column 2](#)), two more control variables. The former is related to the presence of urban amenities in municipalities. In this sense, the regression model points out that there is a positive and statistically correlation between the concentration of urban amenities and per capita income growth between 2001 and 2008 such as the coefficient ( $\beta_8=0,00028^{***}$ ) shows. Thus, the presence of urban amenities in municipalities in 2001 is able to predict the subsequent growth of per capita income since 2001. This is consistent with our hypothesis explained in Section 4.2 at the time that supports the conclusion that per capita income growth decreases as there is less accessibility to the past urbanization and localization economies that have arisen from the CBD and sub-centres, (see, the signs of the coefficients  $\beta_1$  and  $\beta_2$  of the previous [Table 5](#)). Then, related to the latter control variable which is focused on using a geographical dummy variable (coast municipalities), the model reveals that coast municipalities are also positively statistically associated with per capita income growth since 2001 ( $\beta_9=0,07456^{***}$ ). As we mentioned before, as regards the causes of urban inequality, this finding may be consistent with the literature in the sense that it is often suggested that places that hold some kind of natural (geographical) and/or weather advantages compared to other places, tend to enhance the benefits of agglomeration economies, so also per capita income growth.

Finally, we also have taken into account the influence of initial per capita income as a predictor of per capita income growth, presented in ([column 3](#)) of ([Table 5](#)), as a proxy for

observing if there has been a process to convergence between 2001 and 2008 in the Barcelona Metropolitan Region as regards per capita income which is understood as an indicator of social equity. Hence, the statistically significant and positive sign of ( $\beta_7=156,104^{***}$ ) implies that the municipalities that hold the highest per capita income in 2001, its employed population have experienced the highest per capita income growth between 2001 and 2008. This contradicts the convergence hypothesis (Barro and Sala-I-Martin, 1991) which states that cities with different levels of inequality converge to a common level, so there is a negative association between initial inequality and the magnitude of the subsequent growth of per capita income such as the studies of (Glaeser et al., 1995; Glaeser and Shapiro, 2003; Wheeler, 2004; Berry and Glaeser, 2005; Glaeser et al., 2009 and; Glaeser et al., 2012) has pointed out. However, our finding is consistent with the work carried out by (Lee et al., 2013) in which also uses municipalities as a spatial unit under observation in the empirical analysis. Consequently, this result implies that in the Barcelona Metropolitan Region, between 2001 and 2008, there has been a divergence process on the basis of a segregation and polarization dynamic as regards per capita income. This process towards a less social equity in the Barcelona Metropolitan Region, according to the results obtained in the previous (Table 5), has been driven by a) the main centres (CBD and sub-centres) of the metropolitan area because of the regression model results (column 3) are still revealing that proximity to urbanization and localization economies that have emerged from CBD and sub-centres in 2001 predict high subsequent growth of per capita income since 2001 (see, the statistically and expected sign of the coefficient  $\beta_1=-0,00199^{***}$  and  $\beta_2=0,08850^{**}$  respectively) and, b) the progressive concentration of human capital in certain municipalities, what leads a “circle” effect of attracting more and more skilled workers in them (see page 50), what although it requires more empirical work to corroborate, we can say now that it may be possible that these municipalities that concentrate the higher share of human capital among their workers in the Barcelona Metropolitan Region are focused on the central city of Barcelona (CBD) and on the sub-centres. This issue is examined in-detail and corroborated in the study carried out by



## 5. CONCLUSIONS, FINAL REMARKS

In this chapter, our study examine the relationship between urban spatial structure and urban inequality, which is defined through considering its social equity dimension in terms of incomes and without taking into account other dimensions of urban inequality suggested in the literature, for example poverty and criminality rates or the spatial distribution of human capital (skilled workers) across and within metropolitan areas. Thus, our work has attempted to contribute to the current literature as regards urban structure and urban inequality, by a) giving a new perspective of urban scale analysis focused on intra-urban (intra-metropolitan) level compared to other existing studies which are based on inter-urban scale (Wheeler, 2001, 2004, 2008; Glaeser et al., 2009, 2012 and; Glaeser and Resseger, 2010) or based on intra-urban scale but without defining properly the urban structure at this scale (Wheeler, 2008 and; Lee et al., 2013), through an analysis of the influence the central city (CBD) and sub-centres – polycentric structure- exert on social equity on the basis of examining the causes and consequences of urban inequality by using per capita income in 2008 and per capita income growth between 2001 and 2008 as indicators correspondingly, b) filling the lack of empirical

research in these issues in the Barcelona Metropolitan Region due mainly to the best of our knowledge there are no studies in the literature that have studied this point: the influence of urban spatial structure by means of CBD's and sub-centres' effect on the causes and consequences of urban inequality, and finally, c) drawing future policies that enhance social equity (more homogenized per capita income distribution across the space) in the aforementioned study case by using the previous achieved results of sub-centres' and CBD's (polycentric urban structure) influence on per capita income (causes of urban inequality) and its subsequent growth (consequences of urban inequality).

The regression analysis that we carried out in Section 4, reveals that a) urban spatial structure at intra-metropolitan scale exert a statistically influence on per capita income in 2008 and its subsequent growth between 2001 and 2008, so it matters for the causes and the consequences of urban inequality respectively, as a consequence of i) sub-centres and the central city of Barcelona (CBD) are positively and statistically associated with per capita income in 2008 and its growth since 2001, so they predict high per capita income and high per capita income growth what it means that proximity (access to) of urbanization and localization economies that have arisen from these centres (CBD and sub-centres) in the past, in 2001, so dynamic agglomeration economies externalities effects at metropolitan scale, are able to predict the causes of per capita income level 7 years after, in 2008 as well as the consequences of its growth between 2001 and 2008, ii) municipalities with a higher degree of urban compactness, so with higher presence of urbanization economies with effects at local scale, are positively associated with per capita income in 2008 and its subsequent growth until 2008 and finally, iii) functional diversification on the basis of land use balance (diversity of land) exerts also a positively statistically influence on the causes and consequences of urban inequality. Next to this, the regression analysis as regards urban structure effects' also presents that b) the influence of the central city (Barcelona) on per capita income and its subsequent growth is more relevant and significant than the sub-centres' effects at the time that by considering the different nature of sub-centre formation: large and emerging, then the large sub-centres' influence is more prominent than the effect that the emerging sub-centres exert on the causes of per capita income in 2008 and on the consequences of per capita income between 2001 and 2008, and lastly, c) these dynamic agglomeration metropolitan effects that emerge from the central city of Barcelona (CBD) and from the sub-centres conjointly with the tendency of human capital concentration in the large and main municipalities of the metropolitan area are able to explain why there has been a process of divergence and polarization related to the spatial distribution of income instead of a convergence one (municipalities with different levels of inequality converge to a common level) in the Barcelona Metropolitan Region since 2001.

Moreover, in detail, as regards the former analysis on the basis of what are the other determinants that play a significant role to explain the causes of per capita income in 2008 across the municipalities of the Barcelona Metropolitan Region, we can remark briefly that: a) human capital externalities, urban amenities and coast municipalities present a clear positively effect on fostering per capita income, b) the presence of population share above 64 years in municipalities, exert a negatively statistically influence on per capita income level revealing that after a certain point of knowledge accumulation and experience there is no still a positive association between age structure and per capita income, and finally, c) initial conditions of per capita income is positively related to per capita income level after 7 years, what leads to suggest that the convergence hypothesis is not corroborated in the study case of the Barcelona Metropolitan Region. Then, in terms of the second analysis related to what are the factors apart from those are related to urban structure that exert an influence on the consequences of

per capita income growth between 2001 and 2008, we reach on the following three main observations: a) there are not significance changes in terms of the effects that the considered explanatory variables exert related to predict per capita income level in 2008 and its subsequent growth between 2001 and 2008, b) however, the regression models as regards per capita income growth (Table 5) expels in all cases lower values of ( $\beta$ ) coefficient compared to the ones presented in the regression models as regards per capita income level (Table 4), what it suggests that the considered explanatory determinants are more able to predict the causes of urban inequality than their consequences and, c) the positive relation between initial per capita income and the subsequent growth of per capita income between 2001 and 2008 confirms the fact that in the case of the Barcelona Metropolitan Region, the convergence hypothesis is rejected. Thus, it seems that planning a metropolitan area by taking into account centres by means of CBD and several sub-centres could guarantee a balanced distribution across the metropolitan space in terms of income and its growth, so entailing a better social equity (efficiency and cohesion) of this metropolitan area because they are remarkably able to increase over time the level and the growth of the per capita income of their employed workers. This is the case of our study case, the Barcelona Metropolitan Region, in which there are 12 sub-centres evenly distributed across the intra-metropolitan space in 2001, so the empirical results that we reach on this paper may also reveal that polycentric structures (and more in the case of the equipotential ones) improve social equity (there are less urban inequality) compared to other urban structures based on monocentricity (a single core city in the metropolitan area) or dispersion.

Finally, for future research, the results of this work, conjointly with the findings reached on the studies carried out by (Masip, 2012b) and (Masip, 2012c) may entail a revisiting of the compact city concept such as the research conducted by (Masip, 2013-forthcoming) is attempting to propose. In brief, (Masip, 2013-forthcoming) explains that by taking the spatial structure approach of the compact city, although there are many studies in the literature that encourages policy-makers to promote the compact city of dense development focused around downtown (CBD) in order to reduce the need to travel long distances, to consume less energy and resources and to achieve better metropolitan performance, other studies such as (Gordon and Richardson, 1997; Echenique et al. 2012 and; Gaigné et al., 2012) have prospect that it is not a desirable goal due to the negative externalities that generates or that there no significant positive benefits. In that sense, Gaigné's work, pointed out that policy-makers should pay more attention to the various implications of urban compactness due to the increasing-density policy affects prices, wages and land rents which could reshape the urban system and entailing a higher level of negative externalities such as social inequity, congestion and pollution. However, by analyzing the three different models: a) compaction, b) market-led dispersal and c) planned expansion that Echenique's study proposes and by thinking a little bit more about the main results that the present study reaches on: municipalities identified as sub-centres exert a meaningful influence to enhance social equity (efficiency) by means of increase per capita income and its growth due to their urbanization and localization economies that emerge from them. This it brings in mind that in-between of the urban structure models proposed by Echenique's study, a new urban structure model of planning metro areas could emerge, on the basis of the next research question: why we do not propose and promote a urban structure model at intra-metropolitan scale based on a set of compact cities formed by CBD and its surrounding sub-centres?.

Consequently, the achieved results in this paper conjointly with the findings of the previous research conducted by the same author of this work in (Masip, 2012b) and in (Masip, 2012c) could open the way to start a new line of research which focuses on the aim to planning

metropolitan regions and city-regions from taking into account a perspective that reinforces and promotes the productive, inclusive and sustainable places at intra-metropolitan scale. In this sense, in this chapter and in the two other aforementioned studies is corroborated that these places in a metropolitan region coincide with the metropolitan sub-centres that define the polycentric structure of them. Thus, for example (Masip, 2012b) and (Masip, 2012c) complement this current research by showing that sub-centres could exert virtuous influence on achieving a more efficient economic performance at intra-metropolitan scale (they are positively related to labour productivity) at the time that they are also able to be positively associated with social and environmental efficiency by being able to reduce the social and environmental costs due to commuting respectively.

In this way, this new territorial model based on promote the urban development in the metropolitan sub-centres conjointly with the central city (CBD) of the metropolitan region could be of interest for the public administrations, in our case the catalan one, for example '*la Generalitat de Catalunya*' because of the key actors that draws a more efficient metropolitan territorial model from an economic social and environmental perspective are the metropolitan sub-centres of: Sabadell, Terrassa, Granollers, Mataró, Badalona, L'Hospitalet de Llobregat, Rubí (as a large sub-centres), Sant Cugat del Vallès, Martorell, Cornellà de Llobregat, El Prat de Llobregat i Vilanova i la Geltrú, (as emerging sub-centres) conjointly with the central city of Barcelona and their adjacent municipalities. Hence, this proposed territorial model for the Barcelona Metropolitan Region could start a new territorial debate because of the mentioned metropolitan nodes are not the metropolitan nodes and consequently, the territorial model that the Metropolitan Territorial Plan of Barcelona (PTMB) which has approved in 2010, has defined in order to achieve the objectives of economic efficiency, social equity and environmental sustainability. Exactly, the Metropolitan Territorial Plan of Barcelona promotes a nodal structure organized on the central city of Barcelona and on 7 cities which are named as '*les 7 ciutats de l'Arc Metropolità*': Mataró, Granollers, Sabadell, Terrassa, Martorell, Vilafranca del Penedès, and Vilanova i la Geltrú; but it does not carry out an empirical analysis (see, the documents and memories of the Metropolitan Territorial Plan of Barcelona) in order to make evidence that the intra-metropolitan territorial model that it proposes for the Barcelona Metropolitan Region exert an virtuous influence to achieve satisfactorily the three previous mentioned objectives.

At present, with the obtained results in this chapter and in (Masip, 2012b and; Masip, 2012c) we can confirm that: a) certain cities of '*Arc Metropolità*' influence positively in order to reach on the economic, social and environmental efficiency, such as the cities of Sabadell, Terrassa, Mataró and Granollers, but others, for instance in the case of Vilafranca del Penedès its effect is null or in the case of Vilanova i la Geltrú the influence is less significant that the expected and, b) there are municipalities (identified as sub-centres) beyond the 7 cities of '*l'Arc Metropolità*' that are virtuous to enhance the economic, social and environmental performance of the whole metropolitan region of Barcelona. These are the cases of the cities of Badalona, Sant Cugat del Vallès and Rubí for example. In addition, the aforementioned empirical results support the initial and intuitive idea suggested by (Masip and Roca, 2012a) in which proposes a re-definition of the territorial model for Catalunya and for the Barcelona Metropolitan Region based on promoting a bipolar national and metropolitan territorial system. However, more empirical work is needed in order to bring more elements of judgment in the criticism of the nodal territorial model proposed by the Metropolitan Territorial Plan of Barcelona (PTMB) in 2010. In this sense, the research conducted by (Masip and Meijers, 2013-forthcoming) examine the relationship between structure and synergy on the basis of analyzing the shifting division of labour between this 'set of compact

cities' (between sub-centres and, between the central city of the metropolitan region and its surrounding sub-centres) with the objective to promote competition and co-operation strategies (for example smart specialization and smart functional integration) that facilitate to planning a more productive, inclusive and sustainable metropolitan region. Lastly, next to this, the study carried out by (Masip, 2013-forthcoming) aims to define in-depth the pillars of this new re-definition of the compact city concept, which we have just summarized their main ideas in this current work in brief, with the objective that it could be apply on other metropolitan regions, so that it becomes an useful tool for planning new productive, inclusive and sustainable regional developments.

## REFERENCES

- Alonso, W. 1964. *Location and Land Use*, Cambridge, MA: Harvard University Press
- Autor, D.H. and Dorn, D. 2010. Inequality and specialization: the growth of low-skill service jobs in the United States. *MIT Working Paper*:1-52
- Bailey, N. and Turok, I. 2001. Central Scotland as a Polycentric Urban Region: Useful Planning Concept or Chimera?. *Urban Studies*, 38(4):697-715
- Barro, R.J. and Sala-I-Martin, X. 1991. Convergence across states and regions. *Brookings Papers on Economic Activity*, 1:107-182
- Berry, C.R. and Glaeser, E.L. 2005. The divergence of human capital levels across cities. *Papers in Regional Science*, 84(3):407-444
- Black, D. and Taylor, L. 2008. Earnings functions when wages and prices vary by location. *Federal Reserve Bank of St. Louis Working Paper Series*, 2007-031B:1-38
- Brueckner, J.K.; Thisse, J-F. and Zenou, Y. 1999. Why is central Paris rich and downtown Detroit poor? An amenity-based theory. *European Economic Review*, 43:91-107
- Brühlhart, M. and Mathys, N.A. 2008. Sectoral agglomeration economies in a panel of European regions. *Regional Science and Urban Economics*, 38:348-362
- Burger, M.J.; Goei, B. and Laan, L. 2011. Heterogeneous development of metropolitan spatial structure: evidence from commuting patterns in English and Welsh city-regions, 1981-2001. *Cities*, 28:160-170
- Burger, M.J. and Meijers, E. 2012. Form follows function? Linking Morphological and Functional Polycentricity. *Urban Studies*, 49(5):1127-1149
- Carlino, G.A. 1985. Declining city productivity and the growth of rural regions: a test of alternative explanations. *Journal of Urban Economics*, 18:11-27
- Carlino, G.A. and Voith, R. 1992. Accounting for differences in aggregate state productivity. *Regional Science and Urban Economics*, 22:597-617
- Cervero, R. 1996. Mixed Land-Uses and Commuting: Evidence from the American Housing Survey. *Transportation Research Part A*, 30(5):361-377
- Cervero, R. 2002. Built environments and mode choice: toward a normative framework. *Transportation Research Part D*, 7:265-284
- Cervero, R. and Kockelman, K. 1997. Travel Demand and the 3Ds: Density, Diversity, and Design. *Transportation Research D*, 2(3):119-219
- Cervero, R. and Murakami, J. 2010. Effects of built environment on vehicle miles traveled: evidence from 370 US urbanized areas. *Environment and Planning A*, 42:400-418
- Ciccone, A. 2002. Agglomeration effects in Europe, *European Economic Review*, 46:213-227
- Combes, P.P.; Duranton, G. and Gobillon, L. 2008. Spatial wage disparities: Sorting matters!. *Journal of Urban Economics*, 63:723-742

- Combes, P.P.; Duranton, G.; Gobillon, L. and Roux, S. 2010. Estimating Agglomeration economies with history, geology and worker effects, in Glaeser, E.L. (eds.), *Agglomeration Economics*, Chapter 1:15-66. The University of Chicago Press
- 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
- Dahl, G.B. 2002. Mobility and the return to education: testing a Roy Model with multiple markets. *Econometrica*, 70(6):2367-2420
- Davoudi, S. 2003. Polycentricity in European Spatial Planning: From an analytical tool to a Normative Agenda, *European Planning Studies*, 11 (8):979-999
- Di Addario, S. and Patacchini, E. (2008). Wages and the City. Evidence from Italy. *Labour Economics*, 15:1040-1061
- Echenique, M. H.; Hargreaves, A.J., Mitchell, G. and Namdeo, A. 2012. Growing Cities Sustainably: Does Urban form really matter?. *Journal of the American Planning Association*, 78:2:121-137
- Fingleton, B. 2003. Increasing returns: evidence from local wage rates in Great Britain. *Oxford Economic Papers*, 55:716-739
- Fingleton, B. 2006. The new economic geography versus urban economics: an evaluation using local wage rates in Great Britain, *Oxford Economic Papers*, 1-30
- Frank, L.D. and Pivo, G. 1994. Impacts of Mixed Use and Density on Utilization of Three Modes of Travel: Single-Occupant Vehicle, Transit, and Walking. *Transportation Research Record*, 1466:45-52
- Fujita, M. and Krugman, P. 1995. When is the economy monocentric? Von Thünen and Chamberlin unified. *Regional Science and Urban Economics*, 25:505-528
- Fujita, M.; Thisse, J-F. and Zenou, Y. 1997. On the Endogenous Formation of Secondary Employment Centers in a City. *Journal of Urban Economics*, 41:337-357
- Fujita, M.; Krugman, P. and Mori, T. 1999. On the evolution of hierarchical urban systems. *European Economic Review*, 43:209-251
- Gaigné, C.; Riou, S. and Thisse, J.F. 2012. Are compact cities environmentally friendly?. *Journal of Urban Economics*, 72:123-136
- García-López, M.A. and Muñiz, I. 2012. Urban spatial structure, agglomeration economies. and economic growth: An intra-metropolitan perspective. *Papers in Regional Science*, published-online:1-20
- Glaeser, E.L. 2000. The future of urban research: nonmarket interactions. *Brookings-Wharton Papers on Urban Affairs*, 2000:101-149
- Glaeser, E.L.; Kallal, H.D.; Scheinkman, J.A. and Shleifer, A. 1992. Growth in cities. *Journal of Political Economy*, 100:1126-1152
- Glaeser, E.L.; Scheinkman, J.A. and Shleifer, A. 1995. Economic-Growth in a Cross-Section of Cities. *Journal of Monetary Economics*, 36(1):117-143
- Glaeser, E.L.; Kolko, J. and Saiz, A. 2001. Consumer city. *Journal of Economic Geography*, 1:27-50
- Glaeser, E.L. and Maré, D.C. 2001. Cities and Skills. *Journal of Labor Economics*, 19(2):316-342
- Glaeser, E. and Kahn, M. 2003. Sprawl and urban growth. *HIER Discussion Paper*, 2004:1-75
- Glaeser, E. and Kohlhase, J.E. 2003. Cities, Regions and the Decline of Transport Costs. *HIER Discussion Paper*, n°2014:1-54
- Glaeser, E.L. and Saiz, A. 2003. The rise of the skilled city. *Harvard Institute of Economic Research (HIER) Discussion Paper*, 2025:1-68
- Glaeser, E.L. and Shapiro, J.M. 2003. Urban growth in the 1990s: Is city living back?, *Journal of Regional Science*, 43(1):139-165

- Glaeser, E. and Kahn, M. 2004. Sprawl and urban growth. In: *Handbook of Regional and Urban Economics*, vol.4, ed. J.V. Henderson and J.F. Thisse, chapter 56:2482-2527, Elsevier B.V.
- Glaeser, E. and Kohlhase, J.E. 2004. Cities, Regions and the Decline of Transport Costs. *Papers in Regional Science*, 83:197-228
- Glaeser, E.L.; Kahn, M. and Rappaport, J. 2008. Why do the poor live in cities? The role of public transportation. *Journal of Urban Economics*, 63:1-24
- Glaeser, E.L. and Resseger, M.G. and Tobio, K. 2008. Urban Inequality. *NBER Working Paper Series*, n°14419:1-63
- Glaeser, E.L. and Resseger, M.G. and Tobio, K. 2009. Inequality in Cities. *Journal of Regional Science*, 49(4):617-646
- Glaeser, E.L. and Resseger, M.G. 2009. The complementary between cities and skills. *NBER Working Papers Series*, n°1503:1-29
- Glaeser, E.L. and Gottlieb, J.D. 2009. The wealth of cities: Agglomeration economies and spatial equilibrium in the United States. *Journal of Economic Literature*, 47(4):983-1028
- Glaeser, E.L. and Resseger, M.G. 2010. The complementary between cities and skills. *Journal of Regional Science*, 50(1):221-244
- Glaeser, E.L. and Ponzeto, G.A.M. and Tobio, K. 2011. Cities, Skills and Regional Change, Harvard Working Paper:1-62
- Glaeser, E.L. and Ponzeto, G.A.M. and Tobio, K. 2012. Cities, Skills and Regional Change. *Regional Studies*, 1-38, DOI:10.1080/00343404.2012.674637
- de Goei, B.M.; Burger, M.J.; van Oort, F.G. and Kitson, M. 2010. Functional Polycentrism and Urban Network Development in the Greater South East, United Kingdom: Evidence from Commuting Patterns, 1981-2001. *Regional Studies*, 44(9):1149-1170
- Goetz, S.J.; Han, Y.; Findeis, J.L. and Brasier, K.J. 2010. U.S. Commuting Networks and Economic Growth: Measurement and Implications for Spatial Policy. *Growth and Change*, 41(2):276-302
- Gordon, P. and Richardson, H.W. 1997. Are compact cities a desirable planning goal?. *Journal Planning Association*, 63(1):95-106
- Governa, F. and Salone, C. 2005. Italy and European Spatial Policies: Polycentrism, Urban Networks and Local Innovation Practices. *European Planning Studies*, 13(2):265-283
- Graham, D.J. 2000. Spatial variation in labour productivity in British Manufacturing. *International Review of Applied Economics*, 14(3):323-341
- Graham, D.J. and Kim, H.Y. 2008. An empirical analytical framework for agglomeration economies. *The Annals of Regional Science*, 42:267-289
- Graham, D.J.; Melo, P.S.; Jiwattanakulpaisarn, P. and Noland, R.B. 2010. Testing for causality between productivity and agglomeration economies. *Journal of Regional Science*, 50(5):935-951
- Green, N. 2007. Functional polycentricity: a formal definition in terms of social network analysis. *Urban Studies*, 44:2077-2103
- Hall, P. and Pain, K. 2006. *The polycentric Metropolis: Learning from Mega-city Regions in Europe*. (Earthscan, London).
- Harris, T.F. and Ioannides, Y.M. 2000. Productivity and Metropolitan density. *Department of Economics, Tufts University*, 1-26
- Henderson, J.V. 1997. Medium size cities. *Regional Science and Urban Economics*, 27:583-612
- Henderson, J.V.; Shalizi, Z. and Venables, A.J. 2000. Geography and development. *The World Bank, Policy Research Working Paper 2456*:1-42
- Henderson, J.V. and Slade, A. 1993. Development Games in Non-monocentric Cities, *Journal of Urban Economics*, 34:207-229



- Henderson, J.V. and Mitra, A. 1996. The new urban landscape: Developers and edge cities. *Regional Science and Urban Economics*, 26:613-643
- Hohenberg, P.M. and Lees, L.H. 1996. *The Making of Urban Europe, 1000-1994*. Harvard University Press, Cambridge, Massachusetts, and London, England: 1-436
- Hoyler, M.; Kloosterman, R.C. and Sokol, M. 2008. Polycentric Puzzles – Emerging Mega-City Regions seen through the Lens of Advanced Producer Services. *Regional Studies*, 42(8):1055-1064
- Kim, S. 2006. Division of labor and the rise of cities: evidence from U.S. industrialization, 1850-1880. *Journal of Economic Geography*, 1:23
- Kloosterman, R.C. and Musterd, S. 2001. The polycentric urban region: towards a research agenda. *Urban Studies*, 38:623-633
- Krätke, S. 2001. Strengthening the Polycentric Urban System in Europe: Conclusions from the ESPD. *European Planning Studies*, 9(1):105-116
- Lee, S.; Choi, C.G. and Im, W. 2013. Metropolitan growth and community disparities: Insights from the state of New Jersey in the US. *Cities*, 30:149-160
- Lewis, W.C. and Prescott, J.R. 1974. Manufacturing employment, city size, and inter-urban wage differentials. *The Annals of Regional Science*, 8(3):24-38
- Masip, Tresserra, J. 2012a. Toward a methodology to identify and characterize urban sub-centres: Employment Entropy Information versus Employment Density. *RSA Annual European Conference*, Delft 13<sup>th</sup>-16<sup>th</sup> May, 2012:1-38. Chapter 4 of the PhD Thesis: “Policentrisme i emergència de subcentres en la re-estructuració dels sistemes metropolitans cap a la competitivitat i cohesió territorial” (title of the thesis is in Catalan) <http://hdl.handle.net/2177/17812>
- Masip, Tresserra, J. 2012b. Effects of Sub-Centres in Labour Productivity, Firm formation and Urban Growth: Evidence from Barcelona Metropolitan Region. *59<sup>th</sup> Annual North American Meetings of the Regional Science Association International (NARSC)*, Ottawa 7<sup>th</sup>-10<sup>th</sup> November, 2012:1-195. Chapter 5 of the PhD Thesis: “Policentrisme i emergència de subcentres en la re-estructuració dels sistemes metropolitans cap a la competitivitat i cohesió territorial” (title of the thesis is in Catalan) <http://hdl.handle.net/2177/18159>
- Masip, Tresserra, J. 2012c. Sub-Centres and mobility patterns: A study on Social and Environmental Costs due to Commuting in the Barcelona Metropolitan Region. *59<sup>th</sup> Annual North American Meetings of the Regional Science Association International (NARSC)*, Ottawa 7<sup>th</sup>-10<sup>th</sup> November, 2012:1-152. Chapter 6 of the PhD Thesis: “Policentrisme i emergència de subcentres en la re-estructuració dels sistemes metropolitans cap a la competitivitat i cohesió territorial” (title of the thesis is in Catalan) <http://hdl.handle.net/2177/18160>
- Masip, Tresserra, J. and Roca Cladera, Josep. 2012a. Repensant el territori català: cap una bicapitalitat catalana i metropolitana (“Rethinking the Catalan territory: towards a Catalan and metropolitan Bicapital?”). *ACE: Architecture, City and Environment*. Vol.18:100-138. Chapter 2 of the PhD Thesis: “Policentrisme i emergència de subcentres en la re-estructuració dels sistemes metropolitans cap a la competitivitat i cohesió territorial” (title of the thesis is in Catalan)
- Masip, Tresserra, J. and Roca Cladera, Josep. 2012b. Anàlisi retrospectiu del sistema metropolità de Barcelona i la seva influència en l’estructura urbana (“A retrospective analysis of the Barcelona Metropolitan System and its influence on the urban structure”). *ACE: Architecture, City and Environment*. Vol.18:100-138. Chapter 3 of the PhD Thesis: “Policentrisme i emergència de subcentres en la re-estructuració dels sistemes metropolitans cap a la competitivitat i cohesió territorial” (title of the thesis is in Catalan)

- Masip, Tresserra, J. 2013-forthcoming. Effects of the urban spatial structure in economic, social and environmental performances: Evidence from Barcelona Metropolitan Region. *Memòria científica justificativa de la convocatòria de beques per a estades de recerca a l'estranger (BE-DGR2012)* [[Scientific report of the research project funded by AGAUR -Agència de Gestió d'Ajuts Universitaris I de la Recerca- and Catalan Government through the PhD grant, named as BE-DGR2012](#)], March 2013:1-361. This research project is a Chapter of the PhD Thesis: “Policentrisme i emergència de subcentres en la re-estructuració dels sistemes metropolitans cap a la competitivitat i cohesió territorial” (title of the thesis is in Catalan).
- Masip, Tresserra, J. and Meijers, E.J. 2013-forthcoming. Structure and Synergy: Examining the shifting division of labour in the Barcelona Metropolitan Region. *53<sup>rd</sup> European Regional Science Association (ERSA). Regional Integration: Europe, the Mediterranean and the World Economy*. Palermo 27<sup>th</sup>-31<sup>th</sup> August, 2013
- McDonald, J.F., and Prather, P.J. 1994. Suburban Employment Centres: The Case of Chicago. *Urban Studies* Vol. 31(2):201-218.
- Meijers, E.J. and Burger, M.J. 2010. Spatial structure and productivity in US metropolitan areas. *Environment and Planning A*, 42:1383-1402
- Melo, P.C. and Graham, D.J. 2009. Agglomeration Economies and Labour Productivity: Evidence from Longitudinal Worker Data for GB's Travel-to-Work Areas. *SERC Discussion Paper*, 31:1-52
- Mills, E.S. 1967. An aggregative model of resource allocation in a metropolitan area. *American Economic Review*, 57:197-210
- Moretti, E. 2004. Estimating the social return to higher education: evidence from longitudinal and repeated cross-sectional data. *Journal of Econometrics*, 121:175-212
- Muth, R. F. 1969. *Cities and housing, Chicago*, Chicago University Press.
- van Oort, F.G., Burger, M. and Raspe, O. 2010. On the Economic Foundation of the Urban Network Paradigm: Spatial Integration, Functional Integration and Economic Complementarities within the Dutch Randstad. *Urban Studies*, 47(4):725-748
- Parr, J.B. 2004. The Polycentric Urban Region: A closer Inspection. *Regional Studies*, 38(3):231-240
- Peri, G. 2002. Young workers, learning, and agglomerations. *Journal of Urban Economics*, 52:582-607
- Rauch, J.E. 1991. Productivity gains from geographic concentration of human capital: evidence from the cities. *NBER Working Paper Series*, n.3905:1-30
- Rice, P.; Venables, A.J. and Patacchini, E. 2006. Spatial determinants of productivity: Analysis for the regions of Great Britain. *Regional Science and Urban Economics*, 36:727-752
- Rosenthal, S. and Strange, W.C. 2004. Evidence on the nature and sources of agglomeration economies, in Henderson, J.V., Thisse J.F. (eds.), *Handbook of Regional and Urban Economics*, Vol. 4, Chapter 49:2119-2171
- Rosenthal, S.S. and Strange, W.C. 2008. The attenuation of human capital spillovers. *Journal of Urban Economics*, 64:373-389
- Sasaki, K. and Mun, S. 1996. A dynamic analysis of multiple-center formation in a city. *Journal of Urban Economics*, 40:257-278
- Shapiro, J.M. 2005. Smart cities: Quality of life, productivity, and the growth effects of human capital. *National Bureau of Economic Research (NBER) Working Paper*, 11615:1-44
- Shaw, D. and Sykes O. 2004. The concept of polycentricity in European spatial planning: reflections on its interpretation and application in the practice of spatial planning, *International Planning Studies*, 9(4):283-306

- Sveikauskas, L. 1975. The productivity of cities. *Quarterly Journal of Economics*, 89:392-413
- Vandermotten, C.; Halbert, L.; Roelandts, M. and Cornut, P. 2008. European Planning and the Polycentric Consensus: Wishful Thinking?. *Regional Studies*, 42(8):1205-1217
- Vasanen, A. 2012. Functional Polycentricity: Examining Metropolitan Spatial Structure through the Connectivity of Urban Sub-centres. *Urban Studies*, published online: 1-18
- Veneri, P. and Burgalassi, D. 2012. Questioning Polycentric Development and its effects. Issues of Definition and Measurement for the Italian NUTS-2 Regions. *European Planning Studies*, 20(6):1017-1037
- van der Waal, J. and Burgers, J. 2009. Unravelling the Global City debate on social inequality: a firm-level analysis of wage inequality in Amsterdam and Rotterdam. *Urban Studies*, 46(13):2715-2729
- Wheaton, W.C. and Lewis, M.J. 2002. Urban wages and labor market agglomeration. *Journal of Urban Economics*, 51:542-562
- Wheeler, C.H. 2001. Search, sorting, and urban agglomeration. *Journal of Labor Economics*, 19(4):879-899
- Wheeler, C.H. 2004. On the distributional aspects of urban growth. *Journal of Urban Economics*, 55:371-397
- Wheeler, C.H. 2005. Cities, skills, and inequality. *Growth and Change*, 36(3):329-353
- Wheeler, C.H. 2006. Cities and the growth of wages among young workers: Evidence from the NLSY. *Journal of Urban Economics*, 60:162-184
- Wheeler, C.H. 2008. Urban Decentralization and Income inequality: Is sprawl associated with rising income segregation across neighborhoods?. Federal Reserve Bank of St. Louis Regional Economic Development, 4(1):41-57
- Wheeler, C.H. and La Jeunesse, E.A. 2008. Trends in neighborhood income inequality in the U.S.:1980-2000. *Journal of Regional Science*, 48(5):879-891
- Yankow, J.J. 2006. Why do cities pay more? An empirical examination of some competing theories of the urban wage premium. *Journal of Urban Economics*, 60:139-161

## APPENDIX

In this section is reported the results of the determinants of causes and consequences of urban inequality by using Ordinary Least Squares (OLS) techniques.

**Table A1. Spatial determinants of the causes of urban inequality (2008). Regression models estimated by Ordinary Least Squares (OLS): large sub-centres**

Dependent Variable	Y = Ln Per capita income (2008)		
Independent Variables	OLS Model (1)	OLS Model (2)	OLS Model (3)
Constant	3,41621*	10,36221***	5,39024***
(t-value)	(1,73427)	(5,04108)	(3,97652)
(probability)	0,08479	0,00000	0,00010
Distance to Barcelona - CBD 2001	-0,10960***	-0,09044***	-0,05327***
(t-value)	(-4,6444)	(-3,28309)	(-2,99228)
(probability)	0,00000	0,00126	0,00322
Distance to nearest Large Subcentre 2001	3,26125**	2,97901**	2,51048***
(t-value)	(1,96476)	(2,11731)	(2,78616)
(probability)	0,05117	0,035829	0,00600
Population Density 2001 (Ln)	0,68598***	0,33341*	0,17696
(t-value)	(3,59288)	(1,93569)	(1,5981)
(probability)	0,00043	0,05472	0,11207
Land use balance 2001		5,87284***	1,41181*
(t-value)		(4,65632)	(1,64082)
(probability)		0,00000	0,102875
Human Capital-Labor ratio 2001 (Ln)		1,59517***	0,72437**
(t-value)		(3,11960)	(2,17926)
(probability)		0,00216	0,03083
Population above 64 years 2001 (%)		-23,13947***	-11,76181**
(t-value)		(-3,03747)	(-2,38356)
(probability)		0,00280	0,01836
Urban Amenities <sup>A</sup> 2001		0,00831***	0,00301**
(t-value)		(4,27615)	(2,32790)
(probability)		0,00003	0,02121
Coast Municipalities 2001		1,72738**	0,96801**
(t-value)		(2,32165)	(2,02136)
(probability)		0,02155	0,04497
Per capita income 2001 (Gini)			4576,173***
(t-value)			(14,9794)
(probability)			0,00000
Number of observations	164	164	164
R-squared	0,36466	0,57778	0,82816
Adjusted R-squared	0,35275	0,55599	0,81811
F-statistic	30,6121	26,514	92,4649
F (sig)	0,00000	0,00000	0,00000
Log likelihood	-447,204	-413,696	-339,882

\*\*\*, \*\*, \* variables significant at 99 per cent, 95 per cent and 90 per cent respectively

Source: Own Elaboration

Hence, the previous (Table A1) and the following (Table A2) present the results as regards the influence that large sub-centres and emerging ones exert on the causes of urban inequality in the Barcelona Metropolitan Region, measured as per capita income in 2008 respectively.

**Table A2. Spatial determinants of the causes of urban inequality (2008). Regression models estimated by Ordinary Least Squares (OLS): emerging sub-centres**

Dependent Variable	Y = Ln Per capita income (2008)		
Independent Variables	OLS Model (1)	OLS Model (2)	OLS Model (3)
Constant	3,69464*	10,68473***	5,64537***
(t-value)	(1,87201)	(5,19233)	(4,13501)
(probability)	0,06303	0,00000	0,00005
Distance to Barcelona - CBD 2001	-0,11604***	-0,09712***	-0,05873***
(t-value)	(-4,96164)	(-3,55447)	(-3,30897)
(probability)	0,00000	0,00050	0,00116
Distance to nearest Emerging Subcentre 2001	2,09052	2,18638	1,86446**
(t-value)	(1,30860)	(1,59143)	(2,11093)
(probability)	0,19254	0,11354	0,03639
Population Density 2001 (Ln)	0,70320***	0,34065*	0,18239*
(t-value)	(3,66056)	(1,96591)	(1,63030)
(probability)	0,00034	0,05109	0,10508
Land use balance 2001		5,80317***	1,33585
(t-value)		(4,52274)	(1,52207)
(probability)		0,00001	0,13004
Human Capital-Labor ratio 2001 (Ln)		1,62316***	0,74472**
(t-value)		(3,15676)	(2,21837)
(probability)		0,00191	0,02799
Population above 64 years 2001 (%)		-22,67325***	-11,34487**
(t-value)		(-2,96057)	(2,27777)
(probability)		0,00355	0,02411
Urban Amenities <sup>A</sup> 2001		0,00852***	0,00318***
(t-value)		(4,31949)	(2,41199)
(probability)		0,00002	0,01704
Coast Municipalities 2001		1,83509**	1,05679**
(t-value)		(2,45354)	(2,18551)
(probability)		0,01525	0,03036
Per capita income 2001 (Gini)			4589,759****
(t-value)			(14,87402)
(probability)			0,00000
Number of observations	164	164	164
R-squared	0,35622	0,57255	0,82457
Adjusted R-squared	0,34415	0,55049	0,81432
F-statistic	29,5118	25,9528	80,4295
F (sig)	0,00000	0,00000	0,00000
Log likelihood	-448,286	-414,705	-341,676

\*\*\*, \*\*, \* variables significant at 99 per cent, 95 per cent and 90 per cent respectively

Source: Own Elaboration

Next to this, the (Table B1) and (Table B3) reveals whether large sub-centres and emerging sub-centres play a statistically significant growth to the consequences of urban inequality between the period 2001 and 2008.

**Table B1. Spatial determinants of the consequences of urban inequality (2001-2008). Regression models estimated by Ordinary Least Squares (OLS): large sub-centres**

Dependent Variable	Y = Ln p.c. income 2008 - Ln p.c. income 2001 ( Ln 2008 / 2001 )		
Independent Variables	OLS Model (1)	OLS Model (2)	OLS Model (3)
Constant	0,09297	0,34547***	0,17561***
	(t-value)	(1,28460)	(4,51048)
	(probability)	0,20078	0,00001
Distance to Barcelona - CBD 2001	-0,00386***	-0,00321***	-0,00194***
	(t-value)	(-4,45939)	(-3,1299)
	(probability)	0,00001	0,00208
Distance to nearest Large Subcentre 2001	0,12228**	0,10356**	0,08756**
	(t-value)	(2,00501)	(1,97547)
	(probability)	0,04664	0,04999
Population Density 2001 (Ln)	0,02835***	0,01492**	0,00957**
	(t-value)	(4,04153)	(2,32505)
	(probability)	0,00008	0,02136
Land use balance 2001		0,21694***	0,06454*
	(t-value)	(4,61610)	(1,81343)
	(probability)		0,00000
Human Capital-Labor ratio 2001 (Ln)		0,06284***	0,03310**
	(t-value)	(3,29858)	(2,40746)
	(probability)		0,00120
Population above 64 years 2001 (%)		-0,73147***	-0,34276*
	(t-value)	(-2,57684)	(-1,67932)
	(probability)		0,01090
Urban Amenities <sup>A</sup> 2001		0,00027***	0,00009*
	(t-value)	(3,85532)	(1,83439)
	(probability)		0,00016
Coast Municipalities 2001		0,07300***	0,04706**
	(t-value)	(2,63336)	(2,37597)
	(probability)		0,00931
Per capita income 2001 (Gini)			156,338***
	(t-value)		(12,37192)
	(probability)		0,00000
Number of observations	164	164	164
R-squared	0,37646	0,57382	0,78626
Adjusted R-squared	0,36477	0,55182	0,77377
F-statistic	32,201	26,0875	62,9458
F (sig)	0,00000	0,00000	0,00000
Log likelihood	94,6218	125,827	182,415

\*\*\*, \*\*, \* variables significant at 99 per cent, 95 per cent and 90 per cent respectively

Source: Own Elaboration

**Table B2. Spatial determinants of the consequences of urban inequality (2001-2008).  
Regression models estimated by Ordinary Least Squares (OLS): emerging sub-centres**

Dependent Variable	Y = Ln p.c. income 2008 - Ln p.c. income 2001 ( Ln 2008 / 2001 )		
Independent Variables	OLS Model (1)	OLS Model (2)	OLS Model (3)
Constant	0,07260	0,35747***	0,18520***
	(t-value)	(1,43602)	(4,65739)
	(probability)	0,15294	0,00000
Distance to Barcelona - CBD 2001	-0,00413***	-0,00347***	-0,00215***
	(t-value)	(-4,80504)	(-3,40646)
	(probability)	0,00000	0,00083
Distance to nearest Emerging Subcentre 2001	0,07169	0,06573	0,05472
	(t-value)	(1,21999)	(1,28277)
	(probability)	0,22426	0,20148
Population Density 2001 (Ln)	0,00706***	0,01526**	0,00985**
	(t-value)	(4,1181)	(2,3622)
	(probability)	0,00006	0,01940
Land use balance 2001		0,21632***	0,06361*
	(t-value)	(4,52007)	(1,75219)
	(probability)	0,00001	0,08173
Human Capital-Labor ratio 2001 (Ln)		0,06411***	0,03408**
	(t-value)	(3,34284)	(2,45434)
	(probability)	0,00103	0,01522
Population above 64 years 2001 (%)		-0,71100**	-0,32374
	(t-value)	(-2,48905)	(-1,57137)
	(probability)	0,01386	0,11814
Urban Amenities <sup>A</sup> 2001		0,00028***	0,00010*
	(t-value)	(3,86432)	(1,86577)
	(probability)	0,00016	0,06397
Coast Municipalities 2001		0,07661***	0,05000**
	(t-value)	(2,74621)	(2,50008)
	(probability)	0,00674	0,01346
Per capita income 2001 (Gini)			156,900***
	(t-value)		(12,29198)
	(probability)		0,00000
Number of observations	164	164	164
R-squared	0,36669	0,56768	0,78178
Adjusted R-squared	0,35481	0,54537	0,76902
F-statistic	30,8808	25,4418	61,302
F (sig)	0,00000	0,00000	0,00000
Log likelihood	93,3463	124,654	180,714

\*\*\*, \*\*, \* variables significant at 99 per cent, 95 per cent and 90 per cent respectively

Source: Own Elaboration