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Document de treball n.10- 2015

DEPARTAMENT D'ECONOMIA – CREIP
Facultat d'Economia i Empresa

UNIVERSITAT ROVIRA I VIRGILI
DEPARTAMENT D'ECONOMIA

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Edita:

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www.fcee.urv.es/departaments/economia/public_html/index.html
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Adreçar comentaris al Departament d'Economia / CREIP

Dipòsit Legal: T - 361 - 2015

ISSN edició en paper: 1576 - 3382
ISSN edició electrònica: 1988 - 0820

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WHAT EXPLAINS PRODUCTIVITY DIFFERENTIALS ACROSS SPANISH CITIES?

Luis Diaz-Serrano

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Abstract

This paper estimates the determinants of productivity differentials across urban areas in Spain. To do so we resort to Spanish Social Security administrative data (MCVL) matched with workers' fiscal information. We use two-step approach that allows us to control for the confounding effects due to the sorting of more productive workers and more productive firms in bigger cities. Our results indicate that city size is a significant determinant of productivity differentials across Spanish urban areas. We estimate an elasticity of urban agglomeration of 3.3%, which is within the range of values already observed in other countries. We also find that the level of human capital, firm size and the level of industrial specialization also matters in order explain productivity differentials across Spanish cities.

Keywords: Agglomeration, wages, productivity, city size.

JEL codes: R10, R23, J31

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1. Introduction

It is well known that firms and workers are more productive in large cities and large urban areas. Agglomeration and its positive impact on productivity were already discussed by Adam Smith (1776), and during the last decades this positive link has been substantiated by a large number of empirical studies.[1] As a consequence of this, individual earnings, as a measure of individual's productivity, are also higher in bigger cities. Literature providing evidence on the latter link is also quite extensive and unequivocal. Indeed, Combes et al. (2010) find that establishment-level productivity and wages increase with city size with similar elasticity. Workers can be more productive in bigger cities because of two reasons: bigger cities facilitate learning (Glaeser, 1999, Duranton and Puga, 2001), or maybe more productive workers select themselves into bigger cities (e.g. Combes, Duranton, and Gobillon, 2008). Empirical evidence regarding these two previous theories is not unambiguous.[2]

Although literature analyzing the link between city size and productivity is relatively abundant, studies analyzing this issue for the Spanish case are practically non-existent. As far as we are aware De la Roca and Puga (2014) is the only exception. These authors analyze the impact of city size on productivity for workers who remain working for a long period in the same city, compare to those that move. Studies analyzing geographical wage disparities in Spain are also scant, but look at the region as the territorial unit and are based on cross-section data (Garcia and Molina 2002; Motellón et. al. 2011; López-Bazo and Motellón 2012; Simón et al. 2006). These analyses undoubtedly might provide some insights on the territorial wage disparities in Spain. However, we think this approach using regions as territorial unit is not very informative, since wages are subject to a high degree of variability within regions. More specifically, within a region one may observe not only non-negligible wage differentials across cities and urban areas, but also a different pattern in the determination of wages. As in De la Roca and Puga (2014), in this paper we analyze the determinants of productivity differentials, being productivity proxied by wages, across Spanish cities. To do so, we use panel data covering the period 2005-2011 that contains, among other variables, individual wages. However, in contrast to De la Roca and Puga (2014), we focus on a broader group of determinants of city wage differentials, in addition to city

[1] Rosenthal and Strange (2004) and Melo et al. (2009) offer an extensive overview of this literature.

[2] Using Spanish data, De la Roca and Puga (2012) carry out an empirical analysis on these two hypotheses.

size, and use a different definition of urban area.[3] More importantly, we also address a serious drawback in De la Roca and Puga (2014), that is, our analysis focus on hourly wages rather than on annual wages.

Our results indicate that city size is a significant determinant of productivity differentials across Spanish urban areas. We estimate an elasticity of urban agglomeration of 3.3%, which is within the range of values already observed in other countries. We also find that the level of human capital, firm size and the level of industrial specialization also matters in order explain productivity differentials across Spanish cities. Surprisingly, we find little explanatory power of the industrial composition of cities. Further analyses consisting in analyzing the wage gap across urban areas grouped according to their size reveal that if urban areas were endowed with firms of the same size, the wage gap between grand metropolitan areas (Madrid and Barcelona) and the remaining of urban areas in Spain would decrease between 22% and 30%. Analogously, if the endowment of education of the workforce and the type of jobs across all urban areas in Spain was the same, this wage gap would decrease between 40% and 55%.

With the aim described above, the paper is structured as follows. In section 2 we overview of the related literature. In section 3 we describe the data set used in the analysis. Section 4 presents the empirical analysis. Finally, section 5 concludes and summarizes.

2. Review of the literature

2.1. What does international empirical evidence shows?

It has been documented in previous studies that wages are higher in larger cities. As far as firm productivity is closely related to wages, these wage premia reflects that workers and firms in larger cities are more productive. An example of that gap for the United States is provided by Baum-Snow and Pavan (2012): In the 2000 census, average hourly wages of white prime-age men working full-time and full-year were 32% higher in metropolitan areas (MSAs) of over 1.5 million people than in rural areas and MSAs of less than 250 thousand people. Indeed, the relationship between wages and population

[3] In this paper we use the definition of Functional Urban Area (OECD, 2012), while in De la Roca and Puga (2012) urban areas are defined using the classification provided by the Spain's Department of Housing in 2008.

is monotonically increasing by about one percentage point for each additional 100 thousand in population over the full range of MSA size. While empirical research generally finds positive productivity gains from urban agglomeration, estimates vary greatly in magnitude. Rosenthal and Strange (2004) argue that the consensus view of elasticities of urban agglomeration is that doubling urban size increases productivity between 3 and 8%.

The link between city size and wages or productivity has been addressed from the broader discussion about the benefits of cities-known as agglomeration economies. Marshall (1920) provides the first careful economic analysis of agglomeration economies, arguing that cities enhance productivity by allowing for labour market pooling, input sharing, and technological spillovers. An extensive empirical literature has studied agglomeration, including Sveikauskas (1975), Moomaw (1981, 1983), Henderson (1986), Nakamura (1985), Carlton (1983), Glaeser et al. (1992), Gerking (1994), Henderson, Kuncoro, and Turner (1995), and Ciccone and Hall (1996), Eberts and McMillen (1999), and Rosenthal and Strange (2004). These papers mainly focus on whether the advantages of cities depend on city size (urbanization) or employment in a particular industry (localization), on whether agglomerative externalities are static or dynamic, and on the importance of urban diversity.

The first broad question concerns the sources of agglomeration economies. Marshall (1920) suggests three. The first of these is the sharing of inputs whose production involves internal increasing returns to scale. The second is labour market pooling, where agglomeration allows a better match between an employer's needs and a worker's skills and reduces risk for both. The third source is spillovers in knowledge that take place when an industry is localized, allowing workers to learn from each other. Other sources have been suggested more recently. These include home market effects, where the concentration of demand encourages agglomeration, and economies in consumption, where cities exist because people like the bright lights. On the negative side, it has also been suggested that agglomeration is related to rent seeking, with inefficient mega-cities arising more frequently in undemocratic countries.

In her study of the computer industry, Saxenian's (1994) argues that a local industrial system has "three dimensions: local institutions and culture, industrial structure and corporate organization. This view is complementary to that found in Jacobs (1969) and Chinitz (1961), both of whom also suggest that urban efficiencies depend not just on numbers (such as city or industry size) but also on the nature of urban interactions. In the empirical literature, this issue has been considered in Glaeser et al. (1992) and Henderson et al. (1995) by including variables such as the number of employees per firm and the degree of urban specialization. On the discussion on productivity gains from urban scale economies, Melo et al (2009) argue that they can arise from improved access to inter-industry information flows, thick labour markets, better access to specialized services, as well as access to general public infrastructure (such as transport and communications) and public facilities -such as hospitals and schools.

Previous research has also focused on the relative importance of certain industries in agglomeration processes. These studies have found that urbanization economies are generally more important for light industries (Sveikauskas et al.,1988; Nakamura,1985) and knowledge intensive services such as finance, insurance, and real estate (see Duranton and Puga, 2000). Previous studies have also highlighted that the importance of level effects in the wage process for generating wage premia could be generated by a host of underlying mechanisms (Duranton and Puga, 2004). Potential mechanisms include sharing of inputs produced at large efficient scales, sharing risk, and taking advantage of greater opportunities for division of labour. In this respect, Baum-Snow and Pavan (2012) results are consistent with larger cities fostering greater rates of human capital accumulation on the job, or “learning”, especially for more highly skilled workers.

Using data from the NLSY, Baum-Snow and Pavan (2012) confirm that hourly wages are higher and grow faster in bigger cities, and that workers in larger cities have higher observed skill levels. They apply decomposition techniques of log wage growth over the first 15 years of experience that reveal that within job wage growth generates more of the city size wage gap than between job wage growth. They base these decompositions on an estimated on-the-job search model that incorporates latent ability, search frictions, firm-worker match quality, human capital accumulation, and endogenous migration between large, medium, and small cities. Counterfactual simulations of our structural model indicate that returns to experience and wage-level effects are the most important mechanisms contributing to the overall city size wage premium.

The role of skill sorting on determining wage and productivity premia in larger cities has also been objet of numerous investigations. Combes et al (2010) test, using French data, the hypothesis that wage disparities result from spatial differences in the skill composition of the workforce, in non-human endowments, and in local interactions. They find that individual skills account for a large fraction of existing spatial wage disparities, while endowments only appear to play a small role. They also provide strong evidence of spatial sorting by skills and find that interaction effects are mostly driven by the local density of employment. Evidence of the positive sorting on observed skill to larger cities can be also found in Combes, Duranton and Gobillon, 2008). By contrast, Baum-Snow and Pavan (2012) results indicate that sorting on unobserved ability within education group contributes little to observed city size wage premia.

Ciccone (2002) estimates regional agglomeration effects for Europe (France, Germany, Italy, Spain, and the UK). The empirical results suggest that agglomeration effects in these European countries are only slightly lower than in the US and do not vary significantly across countries. The author point out the importance of the effect of changes in industry structure. One of the reasons for this change in industry structure is probably that externalities are stronger in some industries that in others (Henderson, 1974). Furthermore, increasing returns and transportation costs also differ across industries. It has been argued that European economic integration may increase the degree of spatial specialization in Europe, bringing it closer to the pattern in US (Krugman, 1993). This reasoning may also apply to the degree of spatial agglomeration.

2.2. Evidence for Spain

The empirical evidence for Spain on the link between city size and productivity is virtually non-existent. As far as we are aware, De la Roca and Puga (2014) are the only ones analysing this issue. Their findings for Spain are in agreement with the previous results in other countries: individual earnings are higher in bigger cities. They estimate elasticities that ranges from 2.3% to 4.6%. They contemplate three sources of this relationship: spatial sorting of initially more productive workers, static advantages from workers' current location, and learning by working in bigger cities. The authors find that workers in bigger cities do not have higher initial ability as reflected in fixed effects. Instead, they obtain an immediate static premium and accumulate more valuable experience. The additional value of experience in bigger cities persists after leaving and is stronger for those with higher initial ability. This explains both the higher mean and greater dispersion of earnings in bigger cities.

Practically all the analyses regarding productivity differentials in Spain look at the region as the territorial unit and are based on cross-section data. Garcia and Molina (2002) analyze the determinants of wage differentials between the region of Madrid and the remaining Spanish regions. They obtain mixed results; wage differentials between the region of Madrid and Southern regions is due to both heterogeneity across worker characteristics and the remuneration of these characteristics, while in the gap with Northern regions is mainly due to a different remuneration of workers characteristics. However, we find this broad regional classification is not very informative, since Northern regions are quite heterogeneous. The labour markets in Catalonia or the Basc Country are undoubtedly very different from other Northern regions as Galicia or Aragon.

Using firm-employee matched cross-section data, Motellón et. al. (2011) find that most of the wage disparities across Spanish regions are explained by regional heterogeneity in the returns that workers get from individual and firm characteristics. They conclude that differences in the regional distribution of wages are due to increasing differences in the regional return to human capital. Using panel data, López-Bazo and Motellón (2012) reach the same conclusion. However, one question that emerges from this evidence is whether once controls for city size or urban areas are included these differentials in the regional returns to human capital persist. It could be the case that returns to worker characteristics within the same region substantially differ across local labor markets.

Finally, using the same dataset than in Motellón et al. (2011), Simón et al. (2006) finds that collective bargaining plays a major role in accounting for regional wage characteristics. All these studies show that regional wage gaps across Spanish regions are significant and persistent over time. However, any of them have into account the potential role of intra-regional local labour markets in these inter-regional wage disparities. It could be the case that regional wage differential may arise because of the intra-regional composition of local labour markets.

3. Data and selected samples

3.1. Sample

For our empirical analysis, we use the *Muestra Continua de Vidas Laborales,* MCVL, (Continuous sample of working histories), an administrative data set provided by the Social Security Administration. The recently released MCVL contains information of individuals who had an active record with the Social Security system at any time during the years 2005-2011. Each year the sample is a 4% non-stratified random draw from a reference population that includes employed workers (wage earners and selfemployed), unemployment benefits recipients and pension earners. It consists of nearly 1.1 million individuals per year. The MCVL tries to reconstruct the employment and contribution history of the selected individuals. The information available on labor histories dates back to 1967 while earnings records are tracked since 1980.

Variables can be classified in three groups: individual, firm and job characteristics. Individual variables comprise sex, date of birth and death, place of birth, familiar situation, monthly earnings, pension benefits, degree of disability and the year of its beginning. Firm characteristics include number of employees, date of foundation and geographical location. Job variables comprise type of contract, job tenure, social security scheme, firm's sector of activity and dates of beginning and end of each labour contract. Job and firm characteristics are registered for each labor relation in which the worker has been involved. We select individuals that are registered in the Social Security as wage earners between 2005-2011, and use their working histories to construct most of the individual variables used in the empirical analysis. As mentioned above, every labour relation generates a new record containing information about job and firm characteristics. This fact allows identifying the actual working conditions when wages are reported.

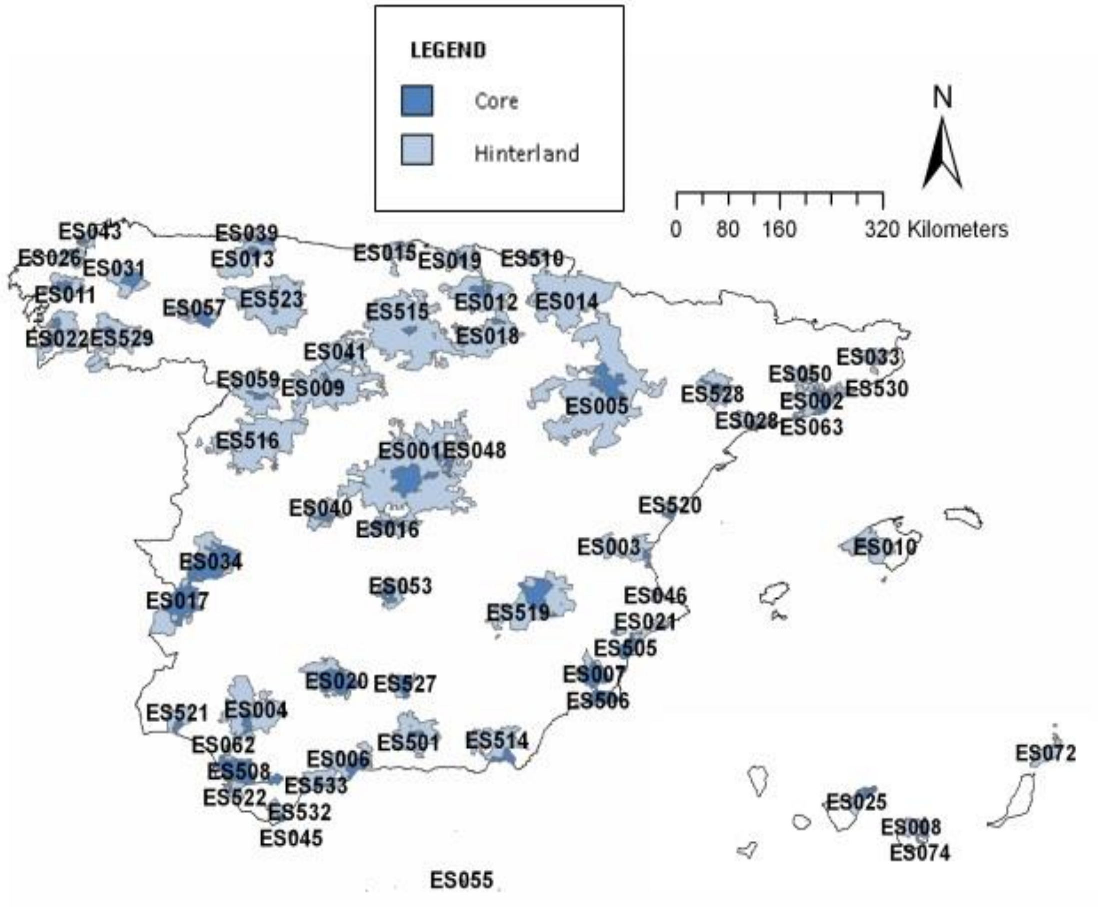
Individual earnings data provided in the MCVL refers to the so called "bases de cotización", which is a censored variable. Lower and upper bounds are defined according to "grupos de cotizacion", which determines the monetary contribution from earnings to social security. Due to this censoring, although this is a quite good proxy of individual earnings it is not precise. However, since 2005, the MCVL records can be matched with the tax records, which contain the summary for each fiscal year of all the withholdings and prepayments of personal income tax on earned income, economic activities, prizes and income imputations. Since, our aim is to analyze wages, this data is suitable as this category of income is well represented by the reliability and the general scope of the tax data for earned income. The same is true of unemployment, pensions, professional activities and a specific range of business activities. This tax records allow us to construct an annual panel of wages covering the period 2005-2011, whit very precise information about individual's earnings. Therefore, we can account for individual wages for all workers in the MCVL for that period.

3.2. Variables

Urban Areas

The definition of urban area used in this paper is the so called Functional Urban (hereafter, FUA). This is a common definition of metropolitan area in the OECD countries. This definition was created by the OECD with the aim to create a standardized territorial unit that allow for an easier and efficient international comparability of the economic, social and environmental performance of metropolitan areas. A FUA would be a "functional economic unit" composed by a number of municipalities.[4] In figure 1, we show the map indicating the Spanish FUAs. As it can be seen in figure 1, each FUA is composed by a group of core municipalities and a group of hinterland municipalities. The OECD defines 76 FUAs in Spain, which represents about 62% of the Spanish population.

Figure 1: OECD classification of the Functional



[4] See OECD (2012) for more details.

In the MCVL, only municipalities with more than 40,000 inhabitants can be identified. This circumstance makes that some of the urban areas as clustered by the OECD in each FUA can be identified only partially. We will be able to identify the core municipalities, but not all the hinterland municipalities. However, we do not expect this circumstance is going to have an impact in our analysis, since the core municipalities comprises most of the population in each FUA. Once we aggregate all municipalities of more than 40,000 inhabitants that can be identified in the MCVL into the 76 FUA defined by the OECD, we still are able to have a number of municipalities representative of 56.4% of the Spanish population. This is not an important loss considering that it is only 10.6 percentage points less than if we were able to identify all the municipalities in the MCVL. In large metropolitan areas (Madrid and Barcelona), we identify the municipalities that represent 92.2% of the population residing in these two FUAs. These per percentages are 74.5%, 77.9% and 88.8% for metropolitan areas, medium sized and small sized urban areas, respectively (see table 1).

Hourly wages

The MCVL contains earnings information from two sources: The social security registers and the income tax module. As we mention above, earnings from the social security registers has lower and upper bounds[5]; therefore, we use annual labour earnings from the income tax module, which are the labour income tax payers declare in their annual income tax declaration. This is a more precise source than labour income in the social security registers. Annual hours worked is constructed from the social security registers. From this source we can reconstruct for each individual in a given year all her contractual relationships, their nature and duration. Hence, we are able to compute the number of hours she has worked in a year. From this we obtain hourly wages.

Table 1: Population represented by the municipalities in each FUA that can be identified in the MCVL (> 40,000 inhabitants)

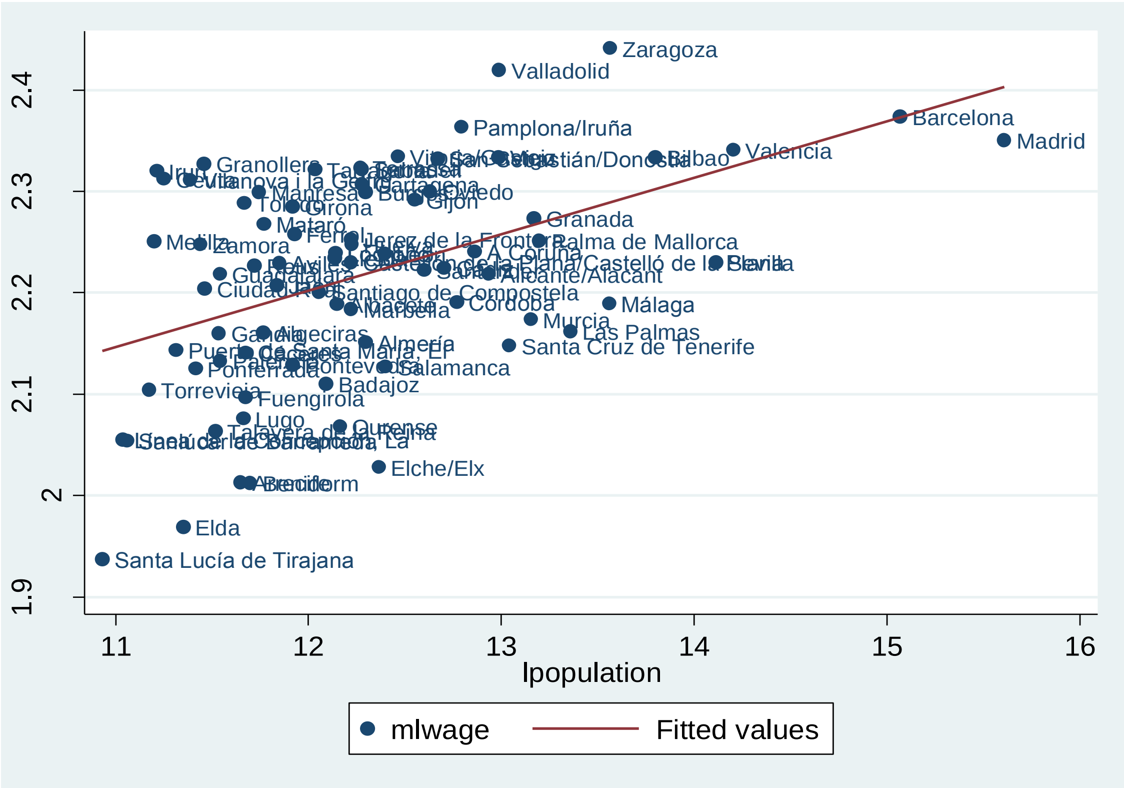
	Real population	Represented population in MCVL	
		Inhabitants	%
Large metropolitan area	9,846,890	9,080,525	92.2%
Metropolitan area	6,045,297	4,504,245	74.5%
Medium sized urban area	7,175,411	5,588,040	77.9%
Small sized urban area	5,510,147	4,895,136	88.8%
Total FUA	28,577,745	24,067,946	84.2%
% Total Spanish population	67.0%	56.4%	

Source: Own computations based in the MCVL

[5] This bounds are 700€ and 3400€ a month and are used to determine the contribution from earnings to the social security system.

In figure 2 we plot average log-hourly wages with some the log of population in each FUA. This figure clearly suggests that the productivity benefits associated with urban agglomerations are positively associated with city size.

Figure 2: Log-hourly wage vs. log of population (average 2005-2011)



Note: 1% of the top of the hourly wage distribution excluded

<u>Individual. job and firm characteristics in the MCVL</u>

The set of individual characteristics are gender, education, a squared polynomial on experience and a dummy variable picking up whether the worker is born in Spain. Job characteristic consists in a set of dummies for the type of occupation and type of contract (full/part time) and a squared polynomial on tenure (years in the current job). From the MCVL we can also consider information regarding the firm: industry, size (number of workers) and age. In table 2 we show a summary statistics of these variables and in figure 3 we plot population size against some of these characteristics. This graph show a clear positive link between population size and workers' education, skills and firm size.

Table 2 Descriptive statistics

	Large Metropolitan Area		Metropolitan Area		Medium Size Urban Area		Small Urban Area	
	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
Log hourly wage	2.359	0.616	2.283	0.647	2.252	0.618	2.207	0.612
Years of education	10.599	4.241	9.639	4.223	9.674	4.121	9.171	4.058
Woman	0.468	0.499	0.453	0.498	0.460	0.498	0.452	0.498
Age	38.255	11.146	38.031	11.063	38.466	11.179	37.824	11.259
Experience	13.793	9.050	14.112	9.010	14.366	9.022	14.058	9.077
Jop tenure	6.272	6.357	5.815	6.180	6.018	6.356	5.633	5.996
Spanish born	0.879	0.327	0.937	0.242	0.937	0.242	0.912	0.283
High skilled worker	0.238	0.426	0.180	0.384	0.165	0.371	0.145	0.352
Medium skilled workers	0.542	0.498	0.563	0.496	0.562	0.496	0.573	0.495
Low skilled worker	0.220	0.414	0.257	0.437	0.274	0.446	0.283	0.450
Part time	0.155	0.362	0.186	0.389	0.174	0.379	0.176	0.381
Agriculture, mining	0.026	0.159	0.031	0.172	0.030	0.172	0.038	0.190
Manufacturing	0.104	0.306	0.093	0.291	0.121	0.326	0.111	0.314
Energy	0.005	0.068	0.009	0.094	0.008	0.087	0.008	0.086
Construcction	0.077	0.266	0.099	0.298	0.094	0.291	0.116	0.320
Commerce	0.181	0.385	0.183	0.387	0.188	0.391	0.197	0.398
Hostelry	0.059	0.236	0.067	0.251	0.073	0.259	0.078	0.269
Transport and warehouse	0.076	0.264	0.072	0.258	0.060	0.238	0.052	0.222
Finance and banking,	0.043	0.202	0.043	0.202	0.047	0.213	0.034	0.181
Real estate, marketing, …	0.226	0.418	0.187	0.390	0.152	0.359	0.132	0.338
Public administration	0.024	0.152	0.033	0.179	0.036	0.187	0.052	0.222
Education, health, social services	0.098	0.298	0.103	0.303	0.115	0.319	0.106	0.307
Other services	0.082	0.275	0.081	0.273	0.075	0.264	0.076	0.266
Log-Firm size	3.835	2.770	3.127	2.376	3.129	2.397	3.127	2.376
Firm age	18.770	19.570	15.788	15.259	16.550	15.885	14.470	13.586
N	946,935		394,864		556,610		393,475	

Figure 3a: Log -firm size vs. log-population

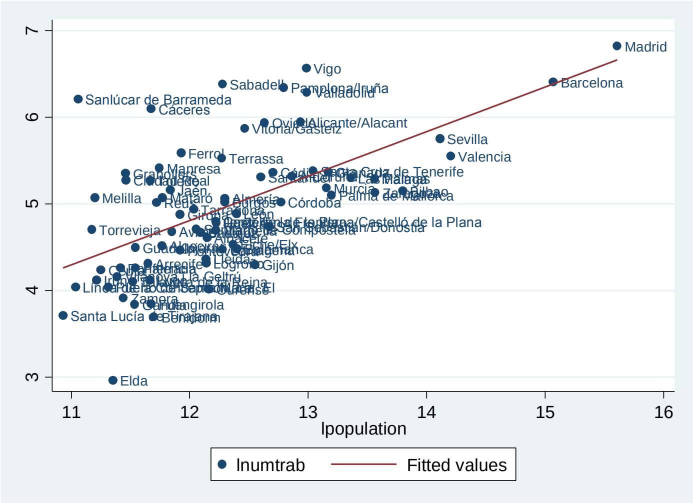


Figure 3b: % workers higher education vs. log-population

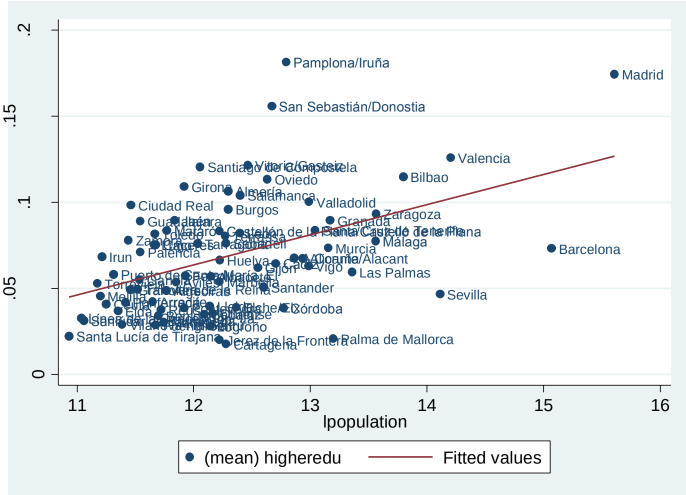


Figure 3c: % high skill workers vs. log-population

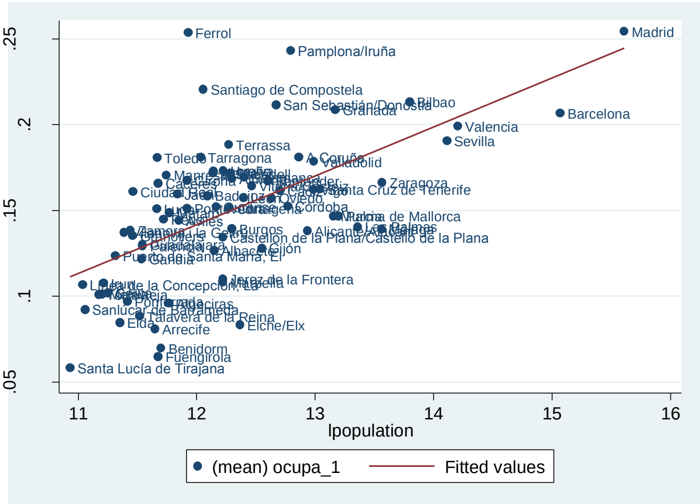
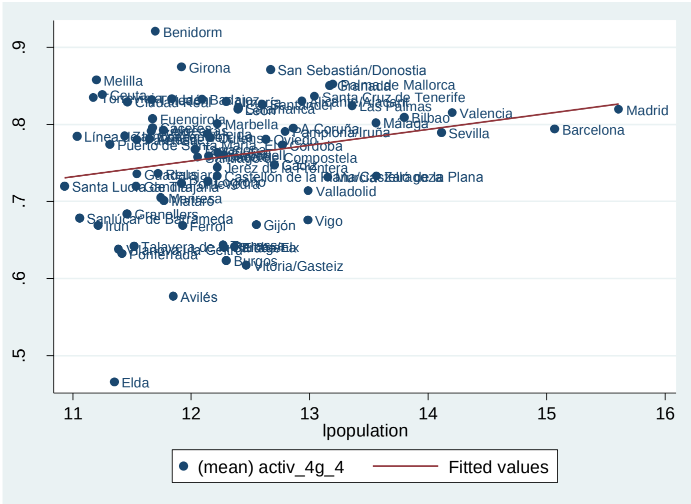


Figure 3d: % blue collar workers vs. log-population



4. Empirical framework and results

4.1. Core specification

In order to explain productivity differentials across FUA, we use the same estimation procedure as in Ahrend et al. (2014). This is a two-step procedure. In the first stage we estimate mincerian individual wage equations

$$log(w_{iat}) = X_{it}'\beta + d_{at} + \varepsilon_{iat} \ , \qquad (1)$$

where w_{iat} are hourly wages of worker i working in FUA a in year t. X_{it} are a set of individual characteristics, d_{at} are time-varying specific urban area fixed-effects and ε_{iat} is a random error term normally distributed. Variables contained in X_{it} are education, age, gender, type of occupation, type of contract (full/par time) and industry. In this stage we account for individual sorting of more skilled individuals into bigger. By doing this we avoid the existence of confounding agglomeration effects with productivity increases from a more skilled workforce. This is the same specification as in Ahrend et al. (2014) .

The estimated fixed-effects d_{at} are picking-up urban wage differentials that persist after controlling for cross-urban workers' characteristics. These differentials can be attributed to several factors as economic conditions, labor market structures, industrial composition, amenities or the aggregated characteristics of the workforce. The latter group of variables would be picking up the effect of workers interaction one to each other on productivity. In order to see whether these factors may explain cross-area wage differentials, in the second stage we estimate the following equation

$$d_{at} = Z'_{at}\gamma + Q_a\mu + \tau_t + u_{at} \ , \qquad (2)$$

where Z_{at} are the set of FUA time-varying characteristics, Q_a are a set of time invariant area specific effects, τ_t are year dummies and u_{at} is an error term normally distributed. The individual controls in the first step account for the composition of the labor force; therefore, d_{at} reflect differential city productivity once we have controlled for sorting and firm characteristics.

In figure 4 we plot the FUA fixed-effects estimated in the first stage against the log of FUA population. As in figure 2, even after controlling for a large set of covariates, the picture practically does not change and again the positive link between productivity and city size is made evident.

In table 3 we report the results of the estimates of equation (1) and (2) used in our two-stage estimation method. In column (1) we show the results regarding the estimation of equation (1), i.e. determinants of individual wages, used in the first stage to estimate the FUA fixed-effects to be used as outcome in the second stage. Columns 2 to 8 report the results of the estimates of the second stage, i.e. determinants of FUA wage differentials.

In this equation (1), column 1, we obtain the standard results in the estimation of mincerian wage equations, i.e. the impact of experience and tenure is inverted U-shaped, negative sign for females and positive for years of education. Regarding the estimates of equation (2), in the most parsimonious model (column 2), we regress wage differentials of cities against population. The estimated elasticity is 3.3%, which means that the average city in a small size urban area is almost 6% less productive than the average city in a medium size urban area, 22% less productive than the average city in a metropolitan area and 117% less productive than the average city in a grand metropolitan area. The estimated elasticity here is within the range of elasticities estimated in De la Roca and Puga (2014).

In column 3 to 8, wage differentials are regressed against FUA population density and surface. In this specification we obtain the impact of population on city productivity remaining city surface constant. In columns 3 to 5, where only density, surface and human capital variables (% of workers with higher education and average experience of workers in the city) are considered, the estimated elasticities for population density are high, significant and with little variation across alternative models. The estimated elasticity ranges between 4.2% and 4.7%. On the contrary, the coefficient associated to city surface reduces its magnitude drastically after considering the human capital variables. According to these results density matters more than city size. Although in models 4 and 5 human capital variables has turned out to be statistically significant, their impact on explaining city productivity is fairly modest. In models 4 and 5, the elasticity associated to the percentage of college graduates is 0.4%, i.e. a 10% increase in the share of college graduates increases productivity by 4%, while a city that increases the average experience of its workers by one year increases its productivity by 1.8%.

However, when other controls are considered; density, surface and human capital variables losses significance, up to the point that in the most complete specification (model 8) these variables are not statistically significant. In models 6 to 8 we also consider industrial diversification, measured by the Herfindahl-Index, in all models this index has turned out to be statistically significant. This index is higher as the degree of industrial diversification increases. City productivity is U-shaped on industrial diversification, i.e. the effect is negative but non-decreasing. In other words, more industrially diversified cities are less productive, but the effect is non-linear and weaker after a given level of diversification.

Another relevant variable in the analysis is the average size of firms located in each city. Estimated elasticities have turned out to be statistically significant in both models where this variable is considered (model 7 and 8). In model 8 the estimated elasticity is 4.3%. This means that a city with an average firm size twice larger than the firm size of other is 4.3% more productive. Indeed, firm size and the Herfindahl-Index are the only variables that survive to the inclusion of the industrial composition, represented by the % of employment in each industry, which on the other hand is not statistically significant.

Figure 4: FUA fixed-effects vs. log(population)

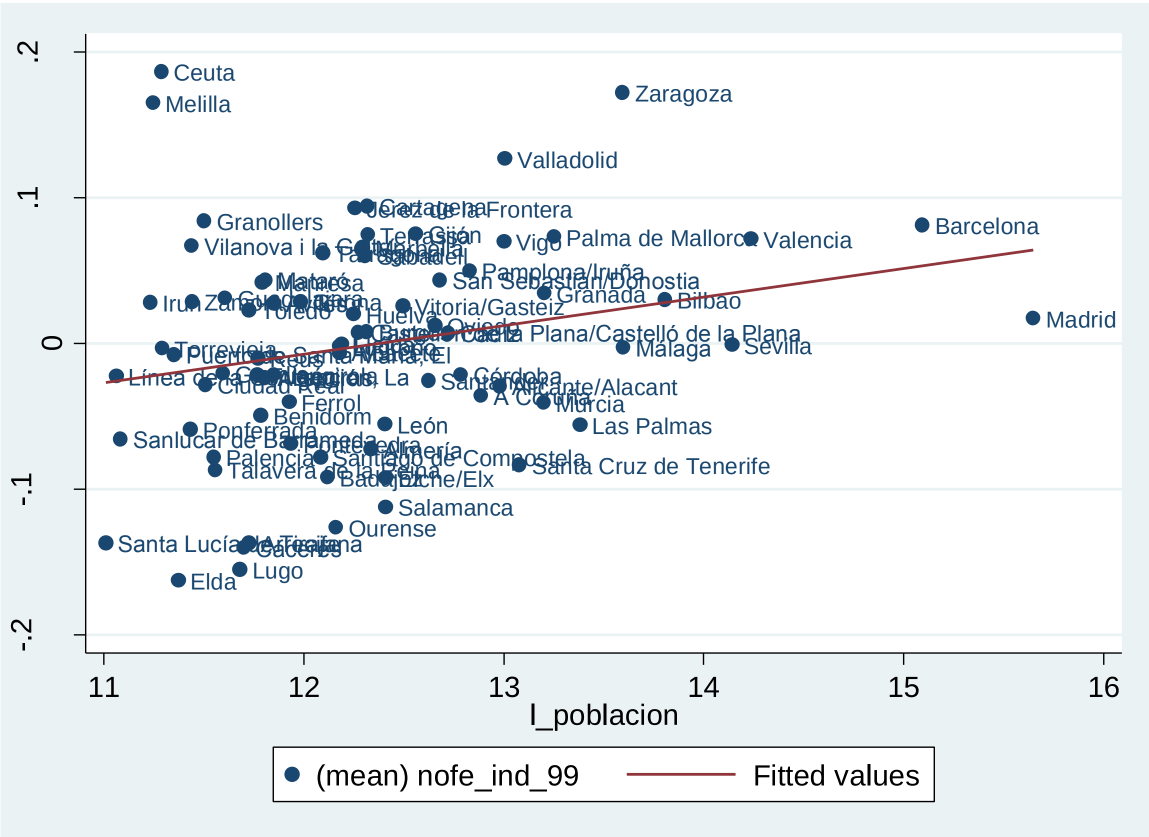


Table 3: Estimates of equations (1) and (2)

	First stage Equation(1)	Second stage Equation(2)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Woman	-0.0938***							
	(0.000799)							
Years schooling	0.0126***							
	(0.000105)							
Age	0.0492***							
	(0.000230)							
Age sq.	-0.000549***							
	(2.84e-06)							
Part time	0.268***							
	(0.00104)							
Medium skilled	-0.339***							
	(0.00106)							
Low skilled	-0.551***							
	-0.0938***							
Log(population)		0.0331***						
		(0.0104)						
Log(density)			0.0475***	0.0423***	0.0431***	0.0346***	0.0214**	0.0061
			(0.0093)	(0.0094)	(0.0087)	(0.0087)	(0.0107)	(0.0140)
Log(surface)			0.0315***	0.0210*	0.0199*	0.0083	-0.0031	-0.0115
			(0.0109)	(0.0110)	(0.0105)	(0.0103)	(0.0115)	(0.0120)
% higher educ.				0.0047***	0.0041**	0.0032*	0.0021	0.0015
				(0.0017)	(0.0018)	(0.0017)	(0.0016)	(0.0016)
Avg. Experience					0.0182*	0.0056	0.0047	0.0173*
					(0.0106)	(0.0109)	(0.0091)	(0.0097)
HHI						-0.00036**	-0.00036**	-0.0003***
						(0.0002)	(0.0001)	(0.0001)
HHI sq.						1.03e-07**	1.03e-07**	6.53e-08*
						(4.84e-08)	(4.51e-08)	(3.76e-08)
Log(firm size)							0.0277**	0.0429***
							(0.0127)	(0.0128)
Agric., mining	-0.136***							0.0005
	(0.00257)							(0.0024)
Manufacturing	0.125***							-9.04e-05
	(0.00165)							(0.00211)
Energy	0.284***							-0.0111
	(0.00457)							(0.0127)
Commerce	-0.00889***							-0.0011
	(0.00152)							(0.0025)
Hostelry	-0.138***							0.0031
	(0.00192)							(0.0027)
Transport, …	0.0893***							-0.0012
	(0.00186)							(0.0024)
Finance & banking	0.298***							-0.0094**
	(0.00219)							(0.0040)
Real estate, …	-0.0620***							0.0024
	(0.00154)							(0.0023)

Public admin.	0.0629***							-0.0004
	(0.00238)							(0.0039)
Educ., health, ...	-0.0493***							0.0004
	(0.00178)							(0.0028)
Other services	-0.228***							0.0082
	(0.00184)							(0.0056)
Constant		-0.541***	-0.613***	-0.571***	-0.790***	-0.274	-0.231	-0.377
		(0.131)	(0.113)	(0.113)	(0.154)	(0.258)	(0.224)	(0.250)
Observations	2,188,767	532	532	532	532	532	532	532
R-squared	0.280	0.334	0.368	0.416	0.443	0.502	0.527	0.605

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

4.2. Alternative specifications

In this section we expand the core specification by considering additional variables in the first stage. Now, in equation (1) we also include as determinants of individual's wages the following variables: a squared polynomial on years of experience and job tenure (years in the same job), a dummy picking-up if the worker is born in Spain and firm characteristics such as firm size and age. This specification is also interesting because we not only account for individual sorting of more skilled individuals into bigger cities, but also for firm sorting of bigger and more productive into bigger cities (see figure 3a). It is well documented that bigger firms pay higher salaries (Oi and Idson 1999).

Results of the extended model are reported in table 4. We obtain that individual wages are inverted U-shaped on years of experience and tenure. Again we obtain a positive sign for part-time workers, while the sign is negative for Spanish born workers. The latter result might be attributable to the fact that legal immigrants with labor contracts are generally more skilled than the average immigrant and the average Spanish worker. We also find that individuals working in bigger and older firms earn more.

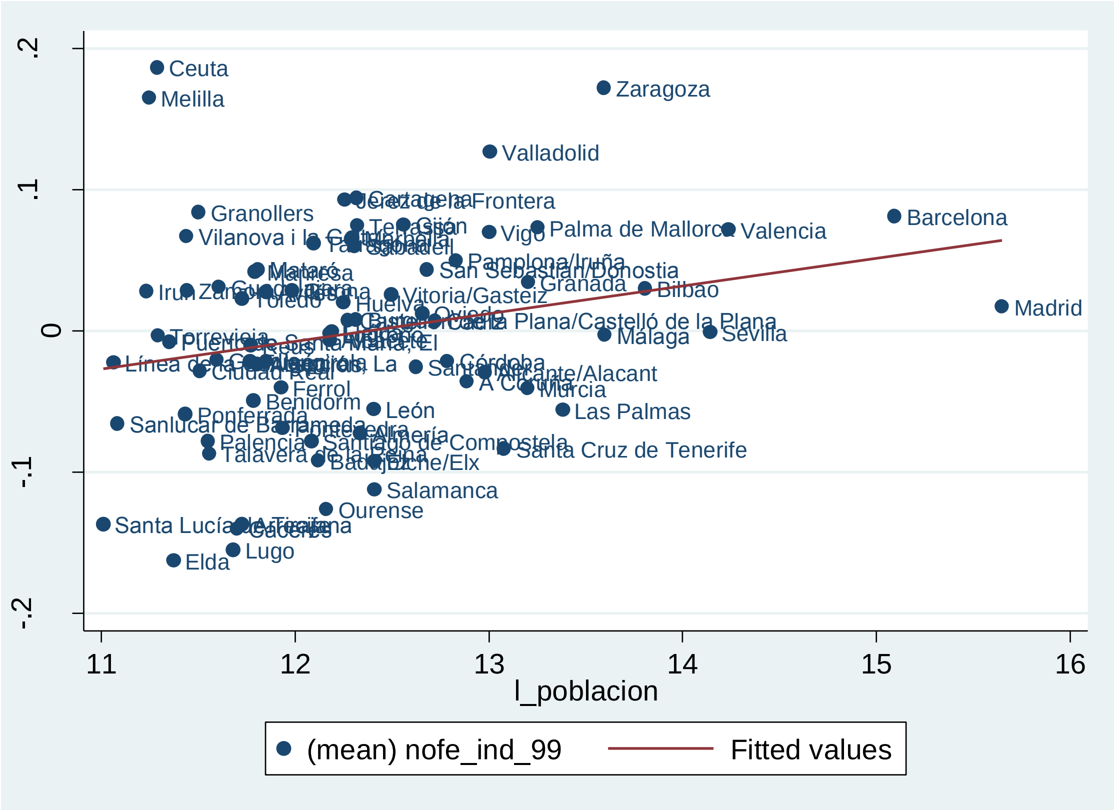
In figure 5, we plot again the FUA fixed-effects estimated in the first stage of this new extended model against the log of FUA population. We observe that after controlling for some additional individual human capital variables and firm characteristics the picture is practically the same as in figures 1 and 4, though the range of values for the fixed-effects obtained from the extended model have changed in a non-negligible way. Columns 2 to 8 in table 4 report the results of the estimates of the second stage, i.e. determinants of FUA wage differentials. We observe some differences if we compare the new results in table 4 with the ones in the core model (table 3). When we regress city productivity differentials against city size we obtain that the estimated elasticity is now 1.9%, almost half of the one reported by the core model (3.3%), which means that part of the agglomeration effects estimated in the core model are indeed retained by the new variables included in the first stage. Regarding the remaining of the variables (models 3 to 8), results are qualitatively the same, though the estimated elasticity for population density is a bit smaller. As in the core model, now the only variables that survive to the inclusion of the industrial composition are again the average size of firms and the industrial diversity represented by the Herfindahl-Index. However, now the size of the elasticities and their significance is a bit weaker.

Table 4: Estimates of equations (1) and (2), extended model

	First stage Equation(1)	**Second stage Equation(2)**						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Woman	-0.0710***							
	(0.0008)							
Years schooling	0.0141***							
	(0.0001)							
Experience	0.0114***							
	(0.0001)							
Experience sq.	-0.0004***							
	(5.21E-06)							
Tenure	0.0463***							
	(0.0001)							
Tenure sq.	-0.0011***							
	(5.27E-06)							
Spaniard	-0.1571***							
	(0.0016)							
Part time	0.3600***							
	(0.001)							
Medium skilled	-0.3150***							
	(0.001)							
Low skilled	-0.4970***							
	(0.0013)							
Log(population)		0.0190*						
		(0.0097)						
Log(density)			0.0373***	0.0337***	0.0342***	0.0266***	0.0207**	0.0131
			(0.0089)	(0.0090)	(0.0087)	(0.0085)	(0.0097)	(0.0133)
Log(surface)			0.0170*	0.0099	0.0093	-0.0008	-0.006	-0.0079
			(0.010)	(0.0104)	(0.0101)	(0.0101)	(0.0108)	(0.0113)
% higher educ.				0.00316**	0.00285*	0.0021	0.0016	0.0007
				(0.0015)	(0.0015)	(0.0015)	(0.0015)	(0.00164)
Avg. Experience					0.00961	-0.0016	-0.0020	0.0054
					(0.0084)	(0.0080)	(0.0073)	(0.00931)
HHI						-0.0003**	-0.0003**	-0.0002**
						(0.0001)	(0.0001)	(0.0001)
HHI sq.						8.1e-08**	8.1e-08**	4.8e-08
						(4.0e-08)	(3.9e-08)	(3.6e-08)
Log(firm size)	0.0347***						0.0125	0.0269*
	(0.00015)						(0.0116)	(0.0137)
Firm age	0.0004***							
	(2.40E-05)							
Agric., mining	-0.1100***							0.0007
	(0.0025)							(0.00222)
Manufacturing	-0.0160***							3.48e-05
	(0.0016)							(0.00199)
Energy	0.0952***							-0.0063
	(0.0044)							(0.0124)
Commerce	-0.1300***							-0.0029
	(0.0015)							(0.0025)
Hostelry	-0.1970***							0.0020
	(0.0018)							(0.0025)
Transport, ...	-0.0311***							-0.0003
	(0.0018)							(0.0023)

Finance & banking	0.1510***							-0.0081**
	(0.0022)							(0.0038)
Real estate, ...	-0.1360***							0.0004
	(0.0015)							(0.0023)
Public admin.	-0.1050***							0.0011
	(0.0023)							(0.0037)
Educ., health, ...	-0.1770***							0.0002
	(0.0017)							(0.00256)
Other services	-0.2970***							0.0056
	(0.0017)							(0.0056)
Constant	1.505***	-0.337***	-0.428***	-0.400***	-0.515***	-0.0653	-0.0460	-0.144
	(0.00467)	(0.122)	(0.104)	(0.106)	(0.146)	(0.204)	(0.190)	(0.231)
Observations	2,189,640	532	532	532	532	532	532	532
R-squared	0.28	0.296	0.366	0.393	0.403	0.462	0.468	0.548

Figure 5: FUA fixed-effects vs. log(population)



4.3. Disentangling the wage gap across urban areas by size

In the previous section we have analyzed the determinants of productivity across Spanish cities using aggregated data at FUA level. Results indicated bigger cities were more productive. We also observe that human capital, industrial specialization and the presence bigger firms favors productivity. Being individual hourly salaries the measure of productivity, in this section we try to explain what determines the wage gap across cities depending on their size. This analysis allows us to quantify the role of observable characteristics and city size on individual productivity.

The OECD classify the FUAs into four types according to their size: grand metropolitan area, metropolitan area, medium-size urban area, small-size urban area. In table 5 we show a summary of hourly wages by FUA type. Gran metro areas (Madrid and Barcelona) represent 41.3% or our sample, while these figures are 17.2%, 24.3% and 17,2% for metropolitan, medium and small size urban areas, respectively. Average hourly wages decrease with the size of the FUA, though wage dispersion does not show any clear pattern.

Table 5: Hourly wages by FUA type (1 % top percentile of hourly wages excluded)

	N		Population	Surface	Population density	Mean	s.d.
Grand metro area	946,935	41.3%	4,932,607	6,450	1,592	12.87	9.63
Metropolitan area	394,864	17.2%	1,026,622	3,514	603	12.27	10.10
Medium size urban area	556,610	24.3%	355,076	2,039	519	11.65	9.20
Small size urban area	393,475	17.2%	135,085	874	655	11.17	9.19

We estimate the following wage equation

$$log(w_{ifat}) = X'_{ift}\beta + \varepsilon_{ifat} \;, \qquad (3)$$

where all the components and subscripts in equation (3) are the same as in equation (1), but now we estimate separate wage equation for each type of FUA f (grand metropolitan area, metropolitan area, medium-sized and small-sized urban area. Note that in contrast with equation (1) in equation (3) we do not include FUA fixed-effects, since these fixed-effects would be capturing, among other potential factors, the potential impact of city size on individual wages. The set of variables considered in equation (3) are gender, years of schooling, nationality (born in Spain or not), experience, job tenure, type of contract (full/part time), occupation, industry, firm size and firm age. Then, we resort to the Oaxaca-Blinder (1973) decomposition to method to decompose the wage gap across FUA type as follows:

$$\hat{Y}_a - \hat{Y}_b = (\bar{X}_a - \bar{X}_b)\hat{\beta}_a + \bar{X}_b(\hat{\beta}_a - \hat{\beta}_b) \;, \qquad (4)$$

where $\hat{Y}$ is the estimate average value of our outcome variable (log-hourly wages) as defined in equation (3) and the subscripts a and b refer to the type of FUA (grand metropolitan area, metropolitan area, medium-sized and small-size urban area), respectively. The left-hand side of equation (4) measures the estimated gap of the log-hourly wage between the two population groups (e.g. grand metro area and small size urban area). The first term on the right-hand side picks up the part of the gap attributed to differences in worker, industry and firm characteristics across FUA types (*endowments*), while the second term concerns the part of the gap caused by differences in the coefficients (*not explained*). This part of gap is due to a different remuneration or impact of the observed characteristics on individual productivity across FUAs of different size. We can assume that these differences between the two types of FUA are picking-up differences in productivity due to city size. As Neumark (1988) suggests, we replace $\hat{\beta}$ for $\hat{\beta}^*$, which is estimated from a pooled model that includes dummy for the type of FUA. We decompose the wage gap between grand metro areas vs. metropolitan, medium-sized and small-size urban areas. Results of the decomposition are reported in Table 6.

The wage gap between grand metro areas and metropolitan areas are practically fully explained by differences in the characteristics of the workforce, industry and firms. This result suggests city size does not play any role in explaining the productivity gap between both types of FUAs. The interpretation is the following: if both groups were endowed with the same observable characteristics, the wage gap would disappear. The interpretation for specific group of variables is analogous, i.e. if workers in both groups were endowed with the same amount of the specific characteristic, the gap will be reduced by the amount reported in table 6. For instance, if workers in grand metro areas had the same education as the workers in metropolitan areas, the wage gap would decrease by almost 20%, and so on. The most important variables explaining the wage gap are type of occupation (high, medium and low skilled) and firm size, 34.5% and 30.5%, respectively. That is, if average size of the firms in both type of FUA were the same, the wage gap would decrease by 30.5%. It is remarkable the poor explanatory power of the industrial composition of the FUA, which impact in explaining the individual productivity gap is practically negligible.

Table 6: Oaxaca decomposition of hourly wages by FUA type

	Grand metro vs. metropolitan		**Grand metro vs. medium**		**Grand metro vs. small**	
Explained						
Individual	0.00758***	10.0%	0.00652***	5.9%	0.00441***	2.9%
Schooling	0.0151***	19.9%	0.0138***	12.5%	0.0205***	13.3%
Job tenure	0.0131***	17.2%	0.00901***	8.2%	0.0164***	10.6%
Part time	-0.0118***	-15.5%	-0.00727***	-6.6%	-0.00832***	-5.4%
Occupation	0.0262***	34.5%	0.0345***	31.4%	0.0425***	27.6%
Industry	-0.00131***	-1.7%	-0.00402***	-3.7%	0.000261	0.2%
Log(firm size)	0.0232***	30.5%	0.0243***	22.1%	0.0378***	24.5%
Firm age	0.00196***	2.6%	0.00121***	1.1%	0.00165***	1.1%
Total	**0.0740*** **	**97.4%**	**0.0781*** **	**71.0%**	**0.115*** **	**74.7%**
Total unexplained	**0.00202* **	**2.7%**	**0.0319*** **	**29.0%**	**0.0388*** **	**25.2%**
Prediction (1)	2.373***		2.373***		2.373***	
Prediction (2)	2.297***		2.263***		2.219***	
Estimated gap	**0.0760*** **		**0.110*** **		**0.154*** **	
Observations	1,276,213		1,434,414		1,273,776	

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

When we compare the individual productivity gap between grand metro areas with medium-sized and small-sized urban areas, we observe that observed characteristics explain only 71% and and 75%, respectively. This result indicates that city size may account for between 25% and 29% of the wage gap between gran metro areas and, medium-sized and small-sized urban areas, respectively. Results are qualitatively the same as before, again the most relevant variables are the type of occupation and firm size, followed by education and job tenure.

As a robustness check, we consider now the following decomposition:

$$\hat{Y}_a^* - \hat{Y}_b^* = (\bar{X}_a - \bar{X}_b)\hat{\beta}_a + \bar{X}_b(\hat{\beta}_a - \hat{\beta}_b), \qquad (5)$$

where now the outcome variable y_i^* is the difference between log-hourly and wages and the estimates FUA fixed effects as in equation (1):

$$y_i^* = log(w_{iat}) - d_{at},$$

y_i^* are hourly wages purged from specific FUA effects. Now we compare the results of equation (5) with those obtained from equation (4) and see if the explanatory power of the observable characteristics has changed. Results are presented in table 7.

Table 7: Oaxaca decomposition of hourly wages by FUA type

	Grand metro vs. metropolitan		**Grand metro vs. medium**		**Grand metro vs. small**	
Explained						
Individual	0.00638***	8.9%	0.00592***	7.7%	0.00385***	3.4%
Schooling	0.0147***	20.6%	0.0139***	18.2%	0.0213***	18.8%
Job tenure	0.0135***	18.9%	0.00929***	12.1%	0.0171***	15.1%
Part time	-0.0117***	-16.4%	-0.00722***	-9.4%	-0.00823***	-7.3%
Occupation	0.0261***	36.6%	0.0342***	44.7%	0.0421***	37.3%
Industry	-0.00161***	-2.3%	-0.00412***	-5.4%	-0.000103	-0.1%
Log(firm size)	0.0224***	31.4%	0.0231***	30.2%	0.0361***	31.9%
Firm age	0.00116***	1.6%	0.000678***	0.9%	0.000895***	0.8%
Total	**0.0709*** **	99.3%	**0.0759*** **	99.2%	**0.113*** **	100.0%
Total unexplained	**0.000514**	0.7%	**0.000599**	0.8%	**6.02e-05**	0.0%
Prediction (1)	2.357***		2.357***		2.357***	
Prediction (2)	2.286***		2.281***		2.244***	
Estimated gap	0.0714***		0.0765***		0.113***	
Observations	1,276,213		1,434,414		1,273,776	

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Given that the specific FUA fixed-effects are capturing wage differentials due to city size, now we observe that observable characteristics explain 100% of the gap in all pairs of groups. Results are qualitatively the same as in table 6. Again the most relevant factors explaining the wage gap between FUA types differing according to its size are type of occupation and firm size, followed by schooling and job tenure.

5. Summary and concluding remarks

This paper estimates the determinants of productivity differentials across urban areas in Spain. To do so we resort to Spanish Social Security administrative data matched with workers' fiscal information. We use two step approach that allows us to control for the confounding effects due to the sorting of more productive workers in bigger cities. Additionally, our data also allow us to control for the sorting of bigger firms, which are more productive, into bigger cities. The latter is not usually considered in the previous empirical studies since this data is not usually available.

The empirical analysis confirms that the benefits of agglomeration tend to increase with city size. We estimate an elasticity of 3.3%, which is line with the one obtained in De la Roca and Puga (2014). Estimated elasticity decreases up to 1.9% once we control form firm size in individual wages. We also estimate elasticities for firm size that ranges between 2.7% to 4.3%. Industrial specialization has also turned out to be significant (positive) explaining productivity differentials across Spanish cities

Further analyses consisting in the use of decomposition technic (Oaxaca-Blinder, 1973) reveal that city size might account between 25% and 29% of the wage gap between individuals working in grand metro areas (Madrid and Barcelona) and workers in medium-sized and small-sized urban areas. Our results indicate that differences in the type of occupations (high, medium and low skill) across differently sized urban areas might account up to 44% of the wage gap. This is most important factor followed by firm size, i.e. if urban areas were endowed with firms of the same size, these wage gaps arising from differences in city size might decrease around 30%. After these two factors, education (19-20%) and job tenure (12-19%) are the other two most relevant factors explaining the wage gap between individuals working in differently sized urban areas.

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