The Role of Establishment Size in the City-Size Earnings Premium*

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Abstract

Both large establishments and large cities are known to offer workers an earnings premium. In this paper, we show that these two premiums are closely linked by documenting a new fact: when workers move to a large city, they also move to larger establishments. We then ask how much of the city-size earnings premium can be attributed to transitions to larger and better-paying establishments. Using administrative data from Spain, we find that 38 percent of the city-size earnings premium can be explained by establishment-size composition. Most of the gains from the transition to larger establishments realize in the short-term upon moving to the large city. Establishment size explains 29 percent of the short-term gains, but only 5 percent of the medium-term gains that accrue as workers gain experience in the large city. The small contribution to the medium-term gains is due to two facts: first, within large cities workers transition to large establishments only slightly faster than in smaller cities; second, the relationship between earnings and establishment size is weaker in large cities.

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1 Introduction

Large cities are places of opportunities. They offer workers both higher wages and faster wage growth over their careers. Understanding what makes large cities so attractive for workers is a primary goal of urban economics, and a large literature has been devoted to understanding the drivers of the city-size earnings premium—the statistical relationship between earnings and city size.[1] A separate literature has been devoted to understanding the establishment-size earnings premium—the statistical relationship between earnings and establishment size.[2] In this paper, we show that the two premiums are closely related. We document that when workers move to larger cities, they also move to larger establishments. Hence, part of the benefit from living in a larger city is due to working at a larger establishment. We ask how much of the city-size earnings premium can be attributed to workers' transitions to better-paying, larger establishments.

To answer this question, we use administrative data on worker-level earnings histories in Spain, and quantify how much of the city-size earnings premium can be explained by establishment size. We find that 38.2 percent of the average earnings gains from moving to a larger city can be attributed to the transition to larger establishments. Part of these gains materialize immediately—the short-term earnings gains—and part will accrue over time as workers accumulate experience in the large city—the medium-term earnings gains.[3] We examine the role of establishment size in generating the short- and medium-term gains separately. We find that the change in establishment size accounts for 29.4 percent of the short-term gains, but only accounts for 4.88 percent of the medium-term gains.

Our results shed light on the drivers of the city-size earnings premium. The quantitative importance of establishment size suggests that the city-size earnings premium may be driven by the same mechanisms that generate the establishment-size premium, such as monopsony, efficiency wages, and rent sharing (Hirsch et al., 2019). However, these theories appear less essential for explaining the medium-term earnings gains of living in a large city. Instead, the medium-term gains are likely to be driven by agglomeration forces typically put forth in the urban economics literature (Duranton and Puga, 2004), such as learning or thicker matching markets, which do not rely on workers moving to larger establishments.

We start by documenting three stylized facts. First, we document the well-known city-size earnings premium. We find that moving to a city twice larger is associated with a 1.63 percent increase in earnings, in line with the findings of De la Roca and Puga (2017) using the same data.

Second, we establish what we call the *co-worker earnings premium*,[4] namely that a transition to an

[1] See Duranton and Puga (2004); Behrens et al. (2014); De la Roca et al. (2014); Combes et al. (2008); Dauth et al. (2019); Baum-Snow and Pavan (2012); Korpi and Clark (2019). For work with the same data see De la Roca and Puga (2017).

[2] See Bloom et al. (2019); Mueller et al. (2017); Berlingieri et al. (2018); Colonnelli et al. (2018); Burdett and Mortensen (1998); Mellow (1982); Brown and Medoff (1989); Bayard and Troske (1999). For work in the same data see Arellano-Bover (2020).

[3] De la Roca and Puga (2017) document the medium-term earnings gains from accumulating experience in larger cities, using the same data.

[4] This is similar to what the literature has called the firm-size or establishment-size earnings premium. We use the terminology "co-worker earnings premium" because our estimates come from worker level data. Rather than estimating

establishment with more co-workers is associated with an increase in earnings. Controlling for observable and time invariant unobservable worker characteristics, we find that doubling the number of co-workers is associated with 1.89 percent higher earnings, similar to estimates from Arellano-Bover (2020) using the same data.[5] We also document that the co-worker earnings premium is decreasing with city size. In Utrera, the smallest city in our sample, the co-worker earnings premium is more than twice as large as the premium in Madrid, the largest city.[6]

Third, we document a new fact, the *city-size co-worker premium*, corresponding to the increase in the number of co-workers associated with a move to a city twice larger. We find that the city-size co-worker premium is large; a worker moving to a city twice as large can expect 25.9 percent more co-workers. While Manning (2010) documents a positive correlation between establishment size and city size using establishment level data in the U.K. and the U.S., as far as we know, we are the first to use panel data to establish that workers moving to larger cities tend to increase their number of co-workers. Further, we show this is true even when controlling for observable characteristics and worker fixed effects.

We combine these facts to decompose the average city-size earnings premium into the contribution of increasing the number of co-workers, hence benefiting from the higher earnings offered by larger establishments, and a remaining "city-premium" not explained by the change in establishment size. Using the average co-worker earnings premium, we find that out of the total 1.63 percent increase in earnings from moving to a city twice as large, 38.2 percent is associated with workers moving to larger establishments.

Next, we move beyond the average city-size earnings premium to investigate the role of the establishment size in both the short-term and the medium-term city-size earnings premium. The short-term earnings gains are defined as the average increase in earnings upon moving to a larger city for a worker with no previous work experience, while the medium-term gains account for the increase in earnings accumulated over time as a worker gains experience in the large city. In order to distinguish between short- and medium-term gains, we include city-specific experience variables to control for experience accumulated in larger cities. Controlling for past experience, we find that moving to a city twice as large is associated with a short-term increase in earnings of 1.87 percent.[7] If we further control for the number of co-workers, we find that the increase in earnings falls to 1.32 percent. Therefore, the transition to larger establishments accounts for 29.4 percent of the short-term city-size earnings premium.

the relationship between average pay per employee and firm size using firm or establishment level data as traditional in the literature on the establishment-size earnings premium, we estimate the relationship between an individual worker's pay and the size of the establishment at which they are employed, i.e. the number of co-workers.

[5] Arellano-Bover (2020) estimates the co-worker earnings premium when a worker first enters the labor market. Nevertheless, the results are similar.

[6] The weaker within-city establishment-size earnings premium in larger cities is consistent with the theory that firms have less monopsony power in large cities (Hirsch et al., 2019). This could drive the sorting of firms that want to grow large to big cities where they will face a more elastic labor supply (Manning, 2010).

[7] Notice that the short-term city-size earnings premium is 0.24 percentage points larger than the average city-size earnings premium, despite earnings increasing faster in larger cities. This is due to a composition effect from experience. We find that accumulating experience in large cities is associated with higher earnings. However, people moving to large cities tend to be younger and have little experience in large cities, so their earnings only increase relatively moderately. On the contrary, people who move to smaller cities tend to have some experience in larger cities, so their earnings fall relatively moderately. This different selection of movers based on their experience leads to a smaller gradient of earnings with city size when we do not control for experience.

Finally, we explore the role of transitions between establishments of different sizes in explaining the medium-term earnings gains offered by large cities. We find that after 9.4 years of experience in a city twice larger, which is the average experience in our sample, workers benefit from an additional 1.17 percent increase in earnings. This is in line with the findings in De la Roca and Puga (2017), who first documented the medium-term gains for Spain.[8]

The medium-term gains from accumulating experience in a larger city could be due to establishment size in two ways: first, workers may transition faster to larger establishments in large cities; second, as workers transition to larger establishments over their careers, they may experience a steeper gradient of earnings with establishment size in large cities—i.e., a larger co-worker earnings premium in large cities. Indeed, we document a slightly faster transition to larger establishments in large cities. However, as reported above, we find that the co-worker earnings premium is actually lower in large cities. This fact dampens the contribution of the faster growth in the number of co-workers: only 4.88 percent of the medium-term earnings gains in larger cities can be attributed to a faster growth in the number of co-workers. Therefore, the medium-term gains are mainly driven by mechanisms that operate for a given establishment size.

This paper primarily contributes to the literature on the city-size and establishment-size earnings premiums. Although the two premiums are typically associated with different mechanisms and separate streams of literature, we show that they are closely related since workers systematically move to larger establishments when they move to larger cities.

While providing a joint theory of the city-size and establishment-size earnings premiums is beyond the scope of this paper, the empirical results we provide can be used to distinguish between existing theories and guide future research. First, the important role of establishment size in accounting for the city-size earnings premium suggests that a successful theory of agglomeration needs to explain the presence of larger, more productive firms in big cities.[9] Second, the theory needs to account for differences in the establishment-size earnings premium across cities. Third, a successful theory would need to account for the limited role of establishment size in generating the medium-term gains of living in a big city. Taken together, these three facts may be satisfied by a model in which firms sort to big cities where they will face a more elastic labor supply curve, as in Manning (2010).[10]

The rest of the paper is organized as follows. Section 2 describes the Spanish administrative data. Section 3 documents the new stylized facts on the co-worker earnings premium and how it varies across cities, the city-size earnings premium, and the city-size co-worker premium. Section 4 presents the main results decomposing the city-size earnings premium into the city premium and the co-worker premium.

[8] Eckert et al. (2019) examine the returns to big-city experience using quasi-experimental data for refugees in Denmark.

[9] As in theories of firm sorting (Gaubert, 2018; Duranton and Puga, 2001; Brinkman et al., 2012; Combes et al., 2012; Manning, 2010).

[10] Hirsch et al. (2019) provides additional empirical evidence for this mechanism. However, we are not aware of any paper which provides a micro-foundation for why there would be differences in monopsony power across cities, a question we view as a promising area for future research.

2 Data Description

This paper uses the Muestra Continua de Vidas Laborales (MCVL). This dataset is maintained by the Social Security Administration (SSA) in Spain and consists of an annual panel from 2006 to 2013.[11] The MCVL sample is selected in two steps. In a first step, an algorithm is designed to select 4 percent of all personal ID numbers in use.[12] The number of individuals in this first selection is regularly expanded by including 4 percent of individuals with newly issued ID numbers every year. In a second step, the selection is refined to include individuals who had a relationship with the SSA, either because they contributed with their labor earnings or because they received unemployment or pension benefits. This two-step procedure results in a 4 percent random non-stratified sample of the population of reference every year. Moreover, the procedure guarantees a panel dimension that follows people across years even as they exit and enter the population of reference. We select only individuals born after 1962, since this is the first cohort for which we can observe the entire labor history. This cohort was 52 years old in 2013.

We further restrict our sample by including employed working-age males born in Spain.[13] We exclude public employees, workers under apprenticeship contracts, co-op workers, employees in agriculture, fishing, forestry, extraction industries, public administration, education, health services and international organizations. We also exclude workers whose contracts specify discontinuous involvement, and individuals who worked for less than the equivalent of 30 days in a calendar year. Finally, the sample does not include individuals working in the Basque Country or Navarre, since these regions keep their own fiscal records which are not managed by the SSA. Section A.2 in the Appendix includes summary statistics of the final sample in Table A.1 and a discussion on how representative it is of the overall Spanish population along different dimensions. We present the definitions of urban area, establishment, employer, experience, and earnings in Section A.1.

One of the advantages of the data is that it includes the complete history of an individual relationship with the SSA since they first entered the labor force. This long-run dimension allows us to construct very detailed information on the work experience of individuals, including the number of years they spent in large cities. Being able to observe their whole labor history is key for our analysis.

3 Establishment-Size Composition and the City-Size Earnings Premium

In this section, we document the three main stylized facts. First, we establish the city-size earnings premium, namely the positive association between earnings and city size. Second, we present the co-

[11] This includes the 2008 financial crisis in Spain, as well as the housing boom leading up to it. Monthly fixed effects are included in the estimation to control for the national trend.

[12] The personal ID number refers to the Documento Nacional de Identidad (DNI) number for nationals, and the Número de Identificación del extranjero (NIE) for foreign nationals. Every resident in Spain is required by law to acquire a DNI by the age of 14.

[13] The reason to not include female workers is that female labor force participation in Spain was extremely low during the 80s and it would significantly affect our measure of labor experience in large cities for the older women in the sample.

worker earnings premium, corresponding to the positive association between earnings and the number of co-workers. We further show that the co-worker earnings premium is not constant across cities. Within Utrera, the smallest city in Spain, co-worker earnings premium is more than twice as large as the premium in Madrid. Finally, we document the city-size co-worker premium, that is, the increase in the number of co-workers associated with living in a larger city.

3.1 Two step methodology

Before documenting the stylized facts, we briefly discuss the methodology. We follow De la Roca and Puga (2017) and employ a two-step procedure. In the first step, we regress the variable of interest on city fixed effects and controls. Second, we regress the city fixed effects on city size.

There are two reasons for employing this two step procedure. First, by using the city fixed effects to estimate the earnings and co-worker premium, we are giving equal weight to cities of different sizes. If instead we ran one regression of individual log earnings on city size, we would over-weight large cities that are better represented in the sample. Second, by doing the estimation in two steps, the city fixed effects absorb all the city-level shocks that would otherwise introduce a correlation structure in the error terms.[14]

To fix notation, we first run the following regression of log earnings w_{it} (or log number of co-workers in some of the specifications) for individual i, at time t:

$$\ln(w_{it}) = \alpha_{c(i,t)} + \delta_t + \mu_i + x'_{it}\psi + \epsilon_{it}, \tag{3.1}$$

where $c(i,t)$ is the city where individual i lives at time t, $\alpha_{c(i,t)}$ is the corresponding city fixed effect, δ_t is a month-year fixed effect, μ_i is an individual fixed effect, x_{it} is a vector of characteristics of worker i at time t which includes education, occupation, sector, experience, tenure, and type of contract; and ϵ_{it} is the residual earnings.[15] For reference, section A.2 of the Appendix includes a table with the summary statistics for the regressors and variables of interest.

In the second step, we regress the estimated city fixed effects on the log of our measure of city size, that is, the population within 10 km of the average person:

$$\alpha_c = \beta \ln(\text{city size}_c) + u_c. \tag{3.2}$$

The city size earnings (or co-workers) premium is then defined as the elasticity of the city fixed effect, that is, the city-level average earnings (or co-workers) with respect to city size. The city size premium will be reported as the increase in earnings (or co-workers) associated with a 100 percent increase in city size. By estimating the city size premium in this way, it is explicit that we treat each city as one observation.

[14] Combes and Gobillon (2015) provide a detailed discussion of the relationship between an equivalent one-step, in which city size is directly introduced as a co-variate, and the two-step procedure.

[15] Note that education does not vary over time for individuals in our sample, it is therefore absorbed by individual fixed effects in the specification where they are included.

Table 3.1: City-Size Earnings Premium, Co-Worker Earnings Premium and City-Size Co-Worker premium

	(1)	(2)	(3)
	Panel A: City-Size Earnings Premium, Second Step		
	Ln Earnings City FE from 1st Step		
Ln City Size	0.0720	0.0471	0.0233
	(0.0106)***	(0.0081)***	(0.0050)***
Observations	76	76	76
R^2	0.312	0.234	0.158
	Panel B: Co-Worker Earnings Premium		
	Ln Earnings		
Ln Co-workers	0.0683	0.0492	0.0270
	(0.0006)***	(0.0005)***	(0.0005)***
Observations	7,308,794	7,308,794	7,308,794
R^2	0.210	0.502	0.449
	Panel C: City-Size Co-Worker Premium, Second Step		
	Ln Co-Workers City FE from 1st Step		
Ln City Size	0.3385	0.3215	0.3319
	(0.0492)***	(0.0480)***	(0.0462)***
Observations	76	76	76
R^2	0.363	0.362	0.469
Month FE	Y	Y	Y
Sector FE	Y	Y	Y
Worker FE	N	N	Y
Controls	N	Y	Y
Observations	7,308,794	7,308,794	7,308,794
R^2 Panel A	0.202	0.491	0.426
R^2 Panel C	0.280	0.298	0.250

Note: panel A reports the results of the second step, consisting in regressing the city fixed effects on log city size. In the first step, we regressed log earnings on city fixed effects and a series of controls. City size is measured as the number of people living within 10km of the average person. Panel B reports the results from regressing log earnings on log establishment workers. An establishment corresponds to a firm-province tax identifier. Panel C reports the results of the second step, consisting in regressing the city fixed effects on log city size. In the first step, we regressed log number establishment workers on city fixed effects and a series of controls. In all three panels, controls include education, occupational categories, industry and time fixed effects, and type of contract. In addition, we control always for month and sector fixed effects. Clustering is implemented at the person level. The information reported in the lower part of the Table on worker fixed effects, controls and the number of observations, refers to the first step of Panel A and C, and to Panel B. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013. $p<0.1$, ** $p<0.05$, ***$p<0.001$.

3.2 Three stylized facts

Table 3.1 presents the three main stylized facts. Panel A shows the city-size earnings premium, or the positive correlation between earnings and city size. The elasticity between earnings and city size is 0.0720, meaning that workers in cities with twice the population have on average 5.12 percent higher earnings.[16] A significant part of this difference can be accounted for by observable characteristics such as sector, occupation, education, experience, tenure, and whether the contract is part time. Once we control for worker characteristics, in column 2, the elasticity of earnings with respect to city size decreases to 0.0471, that is, more than a third of the percentage difference in earnings can be explained by observable characteristics. Finally, in column 3, we control for unobserved worker characteristics by including worker fixed effects. The elasticity between earnings and city size decreases to 0.0233, meaning that a worker moving to a city with twice the size should expect an average 1.63 percent increase in earnings. The earnings premium is about half of the city-size earnings premium before including worker fixed effects.

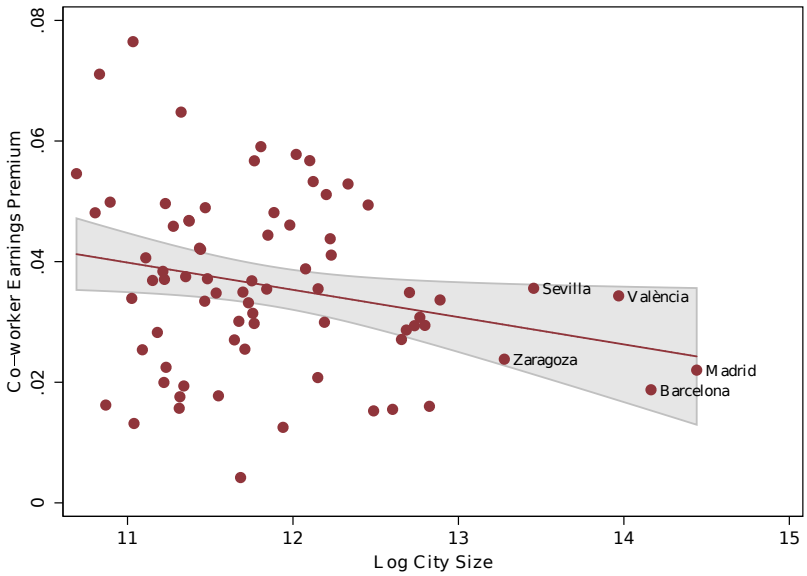
There are two differences between the regressions with and without worker fixed effects that could drive this decrease. First, as intended, the decrease in the observed city-size earnings premium could be due to controlling for sorting based on unobserved worker characteristics. Second, the decrease could be due to the change in the way the city fixed effects are identified once worker fixed effects are included. Without worker fixed effects, the city fixed effects reflect the difference in average residual earnings across cities. With worker fixed effects, the city fixed effects are the difference in average residual earnings for workers who move across cities at least once during our sample period. The earnings patterns of workers who move across cities may be systematically different from workers who never move. Subsection B.1 of Appendix B explores which factor is more important and finds that the city-size wage premium is not substantially different for the population of workers that ever move and that workers who move to a big city are not systematically moving to big establishments. These results suggest that our findings are not driven by selection.

Next, Panel B of Table 3.1, documents the correlation between the number of co-workers and earnings in the data. The elasticity between earnings and the number of co-workers is 0.0683, implying that workers with twice as many co-workers have, on average, 4.85 percent higher earnings. Controlling for a broad set of observable worker characteristics reduces the elasticity to 0.0492. In column 3, we further control for worker fixed effects and evaluate the relevance of unobserved characteristics. The coefficient on log co-workers captures the elasticity between earnings and establishment size for workers who move across establishment sizes. The elasticity decreases to 0.0270, meaning that a worker moving to an establishment with twice as many co-workers should expect a 1.89 percent increase in their earnings. We refer to this increase as the co-worker earnings premium.

Moving to an establishment with more co-workers is associated with large earnings gains. However, it is possible that these gains are not the same across all cities. We calculate the within-city co-worker

[16] The relative increase in earnings y'/y associated to an increase in city size x'/x is equal to $y'/y = (\exp(0.0720 * \ln(x'/x)) - 1)$. If x' is twice the size of city x, then x'/x is 2.

Figure 3.1: Co-worker Earnings Premium by City



Note: This figure plots the coefficient on log number of coworkers on log city size, where the city specific coefficient results from regressing log earnings on sector, time and city fixed effects interacted with log number of workers. City size is the average population within 10 km of the average person. The gray area corresponds to the 95% confidence interval. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.

earnings premium, namely the expected premium from increasing the number of co-workers conditional on staying in the same city, and we show that it is decreasing in city size. Figure 3.1 shows the relationship between the co-worker earnings premium and city size. The within-city co-worker earnings premium is 0.40 percentage points smaller in cities twice as large. In Utrera, the smallest city in our sample, the elasticity of earnings with respect to the number of co-workers is 0.053, while in Madrid the elasticity is only 0.022, that is, 3.1 percentage points lower.

This novel fact has important implications. In decomposing the city-size earnings premium, our goal is to understand what share of the city-size premium is driven by a contemporaneous move to a larger establishment. The fact that the within-city co-worker earnings premium is smaller in large cities means that the expected effect of moving from a small establishment in a small city to a large establishment in a large city will be smaller than the naive estimate of combining the average co-worker earnings premium and the average city-size co-worker premium. We provide more detail on how we calculate the within-city co-worker premium, show the complete set of results with and without worker fixed effects, and further discuss the implications of this novel finding in subsection B.2 of Appendix B.

Finally, Panel C of Table 3.1 documents the positive correlation between number of co-workers and city size. The elasticity of the number of co-workers with respect to city size is 0.3385, meaning that workers in cities with twice the size have on average 26.4 percent more co-workers. Once we control for worker characteristics in column 2, the elasticity only decreases to 0.3215. Finally, controlling for worker fixed effects in column 3 changes the elasticity to 0.3319. The estimates in the three specifications are very close, which suggests that sorting does not play an important role in explaining the city-size co-

Table 3.2: City Size Co-worker Premium by Sector

Tradables		Non-tradables	
Manufacturing	0.456	Real Estate	0.346
	(0.0327)***		(0.0320)***
Communication	0.445	Rental Services	0.374
	(0.0317)***		(0.0331)***
Professional Services	0.454	Construction	0.400
	(0.0321)***		(0.0322)***
Computer	0.402	Retail and Wholesale	0.418
	(0.0316)***		(0.0323)***
Research and Development	0.441	Hotels	0.387
	(0.0346)***		(0.0324)***
Finance	0.443	Transportation	0.393
	(0.0322)***		(0.0324)***
		Entertainment	0.405
			(0.0320)***
		Personal Services	0.425
			(0.0318)***

Note: this table reports the elasticity with respect to city size of a city fixed effect resulting from regressing log establishment workers on city fixed effects sector by sector, controlling for experience, tenure, occupation, type of contract, time fixed effects, and individual fixed effects. City size is the number of people working within 10 km of the average person and an establishment corresponds to a firm-province tax identifier. Clustering is implemented at the person level. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013. $p<0.1$, ** $p<0.05$, ***$p<0.001$.

worker premium. That is, workers who select into larger cities tend to have characteristics that make them higher earners, as shown in Table 3.1, but these characteristics do not make them significantly more likely to work with more co-workers.

It may not come as a surprise that local employment is larger in large cities if firm size is driven by demand. This is what we would expect in service or non-tradable sectors where employment and demand may be tightly linked to the local market size. In order to test whether non-tradable sectors are driving most of the differences in establishment size, we examine the city-size co-worker premium by industry in Table 3.2. The elasticities are similar across all sectors, but the largest elasticities are found in finance, communication, research and development, professional services, manufacturing and computer sectors, all highly tradable sectors while the least tradable sectors such as real estate and hotels present the lowest elasticities. Thus, we conclude that the elasticity of the number of co-workers with respect to city size is not solely driven by local market size.

Table 4.1: The Role of Transitions to Larger Establishments in the Average City-Size Earnings Premium

	(1)	(2)	(3)	(4)
	Ln Earnings City FE from Step 1			
Ln City Size	0.0471	0.0329	0.0233	0.0144
	(0.0081)***	(0.0073)***	(0.0050)***	(0.0048)***
Observations	76	76	76	76
R^2	0.234	0.152	0.169	0.081
	Step 1: Ln Earnings			
Ln Co-Workers		0.0442		0.0269
		(0.0005)***		(0.0005)***
City FE	Y	Y	Y	Y
Worker FE	N	N	Y	Y
Controls	Y	Y	Y	Y
Observations	7,308,794	7,308,794	7,308,794	7,308,794
R^2	0.497	0.519	0.427	0.455

Note: this table reports the results from regressing individual log earnings on city fixed effects and a series of controls, and then regressing the city fixed effects on log city size. City size is the number of people living within 10km of the average person. Controls include education, occupational categories, industry and time fixed effects, and type of contract. Clustering is implemented at the person level. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013. $p<0.1$, ** $p<0.05$, ***$p<0.001$.

4 The Role of Establishment Size in the City-Size Earnings Premium

4.1 The Role of Establishment Size in the Average City-Size Earnings Premium

We start by documenting how much of the city-size earnings premium can be attributed to the city-size co-worker premium. We then document how much of the co-worker earnings premium is due to the fact that workers in large cities have more co-workers. In order to answer these questions, we use the two-step methodology described in the previous section. In the first stage, we regress log earnings on city size fixed effects and workers characteristics, this time controlling for the number of co-workers. In the second stage, we regress the city fixed effects on log city size. We obtain a new city-size earnings premium corresponding to the increase in earnings associated to a transition to a larger city while leaving the number of co-workers unchanged. The results for this exercise are included in Table 4.1.

First, we analyze the change in the city-size earnings premium that results from controlling for the number of co-workers. Column 1 of Table 4.1 reports an elasticity of earnings with respect to city size of 0.0471. This indicates that workers with similar characteristics, not necessarily working with the same

number of co-workers, but living in a city with twice the size have 3.32 percent higher earnings.[17] In column 2 of Table 4.1 we control for the number of co-workers, and the elasticity decreases to 0.0329 meaning that the change in the number of co-workers can account for a third of the city-size earnings premium.

In columns 3 and 4, we account for differences in the selection on time invariant unobserved characteristics by including worker fixed effects in the first stage. In column 3, we obtain an elasticity of 0.0233. This indicates that a worker moving to a city with twice the size and not necessarily staying with the same number of co-workers should expect a 1.63 percent increase in earnings on average.[18] In comparison, when controlling for number of co-workers in column 4, we find an elasticity of 0.0144. The 0.89 percentage points decrease implies that 38.2 percent of a worker's expected increase in earnings in a city with twice the size is associated to the increase in the number of co-workers.

Next, we investigate the change in the co-workers premium as a result of including city fixed effects. In the first step, reported in column 2 of 4.1, we find an elasticity of earnings with respect to the number of co-workers of 0.0442. In comparison, in column 2, Panel B of Table 3.1, the elasticity was 0.0492. Hence, the fact that by comparing workers with different number of co-workers, we may be comparing workers in different cities, can account for at most 10.2 percent of the earnings difference. When we include worker fixed effects to control for unobserved characteristics in step 1 in Column 4 of Table 4.1, we find an elasticity of earnings with respect to the number of co-workers of 0.0269. This is almost the same as the elasticity without controlling for city fixed effects, as reported in column 3, Panel B of Table 3.1. Therefore, the co-worker earnings premium cannot be explained by workers that increase their number of co-workers by simultaneously moving to a larger city.

4.2 Decomposing the Short-Term and Medium-Term Effects of Establishment Size

Until now, we have focused on the effect of increasing either city size or the number of co-workers on a workers' average earnings over the years they are present in the sample, since we were not controlling for the fact that some workers had accumulated experience in large cities and others in small cities. Previous work by De la Roca and Puga (2017) documented that experience accumulated in larger cities results in faster earnings growth, and that this accounted for a significant fraction of average city-size earnings premium. In this section, we look at the effect of controlling for the number of co-workers on the estimation of both the short-term effect and the medium-term effect of moving to a larger city separately. We test whether accumulating experience in larger cities may increase earnings in part by allowing workers to move to establishments with more co-workers. If this is the case, controlling for the number of co-workers would reduce the positive effect of large-city experience on earnings.

In order to separate the short-term and medium-term effects, we follow the two-step procedure used by De la Roca and Puga (2017). In a first step, we regress log earnings (or log number of co-workers) on city fixed effects and the number of years of experience working in each of the cities. We assume that wages for individual i, at time t are given by:

[17] Column 1 of Table 4.1 reproduces the city-size earnings premium obtained in column 2, Panel A of Table 3.1.
[18] Column 3 of Table 4.1 reproduces column 3, Panel A of Table 3.1.

$$\ln(w_{it}) = \alpha_{c(i,t)} + \sum_{g=1}^{G} \left(\delta_{gh(c(i,t))} e_{igt} + \gamma_{gh(c(i,t))} e_{igt}^2\right) + \mu_i + x_{it}'\beta + \epsilon_{it}, \tag{4.1}$$

where $c(i,t)$ is the city where individual i lives at time t, $\alpha_{c(i,t)}$ is a city fixed effect. In principle, the experience accumulated by a worker in any of the C cities may have a different effect on their earnings depending on which city they are currently located. This would imply estimating C^2 coefficients for the effect of experience. In order to maintain sufficient explanatory power, we group cities into G size bins. We define the experience e_{igt} as the number of years individual i worked in cities that belong to group g up to time t. We also group each of the C cities in which workers are located into H size bins and denote by $h(c(i,t))$ the bin to which worker i's current city $c(i,t)$ belong. We allow the experience accumulated in each of bin g to have a specific effect on earnings in each bin h. We set $G = 3$, corresponding to small, medium and large cities, and set $H = 2$. Hence, we effectively allow experience accumulated in small, medium or large cities to affect earnings differently in small or large cities. The coefficients δ_{gh} and γ_{gh} represents the effect of experience and experience squared, respectively, acquired in cities in bin g when the worker is currently in a city in bin h. The remaining terms include an individual fixed effect μ_i and observable characteristics of the worker x_{it}.

We define the short-term city-size premium β^{st} as the coefficient on log size from the following regression:

$$\alpha_c = \beta^{st} \ln(\text{city size}_c) + u_c. \tag{4.2}$$

The medium-term city-size premium β^{mt} is defined as the coefficient on log size from the following regression:

$$\alpha_c + \delta_{g(c)h(c)}\text{mean experience} + \gamma_{g(c)h(c)}\text{mean experience}^2 = \beta^{mt} \ln(\text{city size}_c) + u_c, \tag{4.3}$$

where "mean experience" is equal to the average number of years of experience that workers have in their current city (9.4 years). Hence, the medium-term city-size premium captures both the short-term earnings gains and the specific speed of earnings growth with experience associated to living in a city of a specific size.

The results are shown in Table 4.2. For the reasons discussed in Section 4.1, we include worker fixed effects in all the regressions. First, we decompose the short-term city-size earnings premium into the part that is associated with the increase in the number of co-workers, and the part that is independent of the number of co-workers. In column 1, the short-term city-size earnings premium is 0.0267. This implies that a worker moving to a city with twice the size should expect a 1.87 percent short-term increase in earnings. This increase includes the effect of the increase in the number of co-workers. In column 2, after controlling for the number of co-workers, the short-term city-size earnings premium decreases to 0.0189. This corresponds to a 1.32 percent increase in earnings from moving to a city with twice the size. Therefore, the increase in the number of co-workers can account for 29.4 percent of the short-term city-size earnings premium.

Table 4.2: The Role of Transitions to Larger Establishments for Short-Term and Medium Term City-Size Earnings Premium

	(1)	(2)	(3)	(4)
	Short-Term: Ln Earnings City FE from Step 1		Medium-Term: Ln Earnings City FE Plus City-Size Specific Experience from Step 1	
Ln City Size	0.0267	0.0189	0.0441	0.0355
	(0.0050)***	(0.0047)***	(0.0102)***	(0.0092)***
Observations	76	76	76	76
R^2	0.214	0.135	0.363	0.301
	Step 1: Ln Earnings			
Ln Co-Workers		0.0267		0.0267
		(0.0005)***		(0.0005)***
City FE	Y	Y	Y	Y
Worker FE	Y	Y	Y	Y
City-Specific Experience	Y	Y	Y	Y
Controls	Y	Y	Y	Y
Observations	7,019,750	7,019,750	7,019,750	7,019,750
R^2	0.389	0.425	0.389	0.425

Note: The top part of the Table reports the results of the second step. Column 1 and 2 consist in regressing the city fixed effects on log city size. Columns 3 and 4 consist in regressing the city fixed effects, augmented by the effect of average experience in the city, on city size. In the first step, reported in the bottom part of the Table, we regressed log earnings on city fixed effects and a series of controls. City size is the number of people living within 10km of the average person. Controls include education, occupational categories, industry and time fixed effects, and type of contract. Clustering is implemented at the person level. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013. * p<0.1; ** p<0.05, ***p<0.01.

Next, we decompose the medium-term city-size earnings premium. In column 3, the medium-term city-size earnings premium is 0.0441. Hence, a worker moving to a city with twice the size should expect a 3.10 percent increase after 9.4 years. Thus, the medium-term benefit of moving to a large city is 1.23 percentage points (to get the medium-term benefit, we subtract the 1.87 percentage point short-term benefit from the total medium-term gain of 3.10). In Column 4, the medium-term city-size earnings premium, controlling for the number of co-workers, is 0.0355. This implies that a worker moving to a city with twice the size and maintaining the same number of co-workers should expect a 2.49 percent increase after 9.4 years. Therefore, once we control for the number of co-workers, the medium-term benefits are 1.17 percentage points. Thus, only 4.88 percent of the medium-term gains of large cities can be accounted for through the effect of large-city experience on the number of co-workers.

The small contribution of establishment size to the medium-term gains can be explained by two facts. First, as documented in Section 3.2, the co-worker earnings premium is lower in larger cities. The smaller co-worker earnings premium in larger cities dampens the moderate medium-term gains in the number of co-workers, resulting in a small contribution of establishment size to the medium-term city-size earnings premium. Second, workers in large cities transition to larger establishments only slightly faster than workers in small cities. In Section B.3.1 of the Appendix, we find that the short- and medium-term city-size co-worker premiums are of similar magnitude, indicating that, although workers transition to establishments with more co-workers when they move to a larger city, they move up the establishment-size ladder only slightly faster as they accumulate experience in large cities.

In all our specifications so far, we assumed that the value of experience was similar for all workers, irrespective of their number of co-workers. If experience is more valuable in larger establishments, part of the medium-term gains of accumulating experience in large cities could be due to the fact that individuals in large cities have more co-workers. We examine this possibility in Section B.3.2 of the Appendix, and find that the value of experience does not vary significantly with the number of co-workers. Thus, including these interactions cannot account for the medium-term earnings gains.

5 Conclusion

This paper employs administrative data from Spain to document several stylized facts: the city-size earnings premium, the co-workers earnings premium, the city-size co-worker premium, and the relationship between the within-city co-worker earnings premium and city size. Once these facts are established, we ask how much of the first fact, the city-size earnings premium, can be explained by the fact that workers in large cities have more co-workers and that having more co-workers is associated with higher earnings. We find that around 29 percent of the short-term and 5 percent of the medium-term city-size earnings premium can be attributed to the fact that workers who move to larger cities also transition to better-paying larger establishments. These results highlight the importance of understanding why larger cities host larger establishments. Finally, the novel evidence we present on the negative correlation between the within-city co-worker earnings premium and city size is consistent with theories featuring imperfect labor markets and a more elastic labor supply in large cities. This could explain the part of

the city-size earnings premium that is associated with differences in the establishment-size composition.

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A Data Appendix

In this appendix, we provide some additional information about our dataset. First, we give detailed definitions of the main variables we use. Second, we provide summary statistics for the main variables in the dataset and discuss how they compare to statistics from the EU Labor Force Survey. Finally, in Section A.3 we discuss our decision to focus on establishment size rather than firm size in the main results of the paper.

A.1 Data Definitions

Urban Area. The most disaggregated geographical level at which we observe people's location is a municipality. There are 8,131 municipalities in Spain, with an average area of 62.2 km^2 and an average population of 5,746 inhabitants per municipality. We group municipalities into urban areas using the official definition for urban areas published by Spain's Ministry of Housing in 2008. We exclude urban areas with less than 40,000 inhabitants because in these cases a workplace municipality is not provided for anonymity concerns. Moreover, the sample does not include the autonomous cities of Ceuta and Melilla, and urban areas in the Basque Country and Navarre because they have an independent social security administration. The final sample includes 76 urban areas, 156,212 persons, and 7,308,794 person-month observations. We employ the measure of city size calculated by De la Roca and Puga (2017). They measure the size of an urban area by computing the number of people within 10 km of each inhabitant in the urban area and taking the average. The result is the number of people within 10 km of the average person. This measure is intended to capture the fact that for an individual the relevant size of a city may not only depend on overall population, but also on how spatially concentrated is the population. As showed in De la Roca and Puga (2017), the measures of density are very highly correlated with total population counts. In order to calculate this measure of city size, it is necessary to have a detailed grid of the population in Spain. De la Roca and Puga (2017) use the 1km by 1km population grid that Goerlich and Cantarino (2013) calculated for 2006, and we use the density in 2006 as a time-invariant measure of city size.

Definition of an establishment. To define establishments, we use the Código de Cuenta de Cotización (CCC), a tax identifier used for contributions to Social Security that is associated with an employer-province pair. If a firm has many plants in a province, these will usually be grouped under the same CCC. Thus, our definition of establishment does not necessarily identify each physical plant location of the firm, but gives a disaggregation of the firm at the province level. A potential drawback of this measure, is that in some cases a firm may have more than one CCC in a province as required for administration purposes. In practice, only 1 percent of the city-firm pairs in the sample have more than one CCC. Throughout the paper, we refer to the employer-province pair as establishment to distinguish it from the firm, which spans all provinces.

Consequently, the number of co-workers refers to the number of workers associated with a CCC and not a physical plant. Ideally, we would have information on the number of co-workers within the same urban area. However, since the CCC identifies a firm-province pair, it includes co-workers at

plants located in different urban areas of the same province. In practice, this is a limited concern since provinces are small and most have only one urban area. It is worth noting that the location of the worker is precisely known. But a worker in an urban area will be assigned as co-workers all the individuals working for the same firm in the whole province.[19]

Finally, although we observe the number of co-workers for each worker in the sample, we do not observe any characteristics of these co-workers. Only 26% of the establishments have more than one worker in the sample. As a result, although we have a good measure of the number of workers in a firm, we do not observe enough of them to estimate firm fixed effects.

Employer Tax ID. On top of the CCC we also observe the tax identifier of the employer to which all the CCC belong. We can therefore observe whether a worker works for a firm with multiple establishments in different provinces and the total number of workers employed at that firm. In Section A.3 of the Appendix, we test whether the establishment or the firm co-workers seem more relevant for determining the co-worker earnings premium. We find that firm co-workers is no longer associated with higher earnings when controlling for establishment co-workers, and therefore we continue our analysis using establishment co-workers. We check the robustness of the results looking at firm co-workers instead of establishment co-workers in Section A.3 of the Appendix.

Experience. We are particularly interested in constructing variables capturing aspects of accumulated experience in an urban area. In order to construct urban area variables, we aggregate workplace municipalities to the definition of an urban area. We use the information to construct variables on experience accumulated in different city-size categories following the method of De la Roca and Puga (2017).

Earnings. In order to obtain monthly uncapped labor earnings, we combine information from two sources. First, the social security records include monthly top-coded earnings that exclude payment of over-time hours and other in-kind payments. Second, the tax administration records include all monetary and in-kind labor earnings in a given year and is not top-coded. We allocate the labor earnings from the tax administration across months according to the fraction of top-coded earnings from the social security records that was earned in each month. Earnings are deflated using the Consumer Price Index and converted into 2009 euros, and are then adjusted using the part-time coefficient to measure the full-time equivalent real daily earnings.

A.2 Summary statistics

This section, presents summary statistics on the dependent variables and the controls. Our final sample includes 7,308,794 monthly-person observations corresponding to 156,212 individuals.[20] Table A.1 in-

[19] There is a total of 50 provinces in Spain but due to regional differences in tax collection autonomy we do not have data for four provinces: Bizkaia, Gipuzkoa, Araba, and Navarra. The final sample includes 46 provinces. Most provinces contain only one urban area. The province of Alicante has 7 urban areas, 8 other provinces have 3 urban areas and 10 have 2 urban areas.

[20] On average we observe 45 months per person. Note that 156,212 is 4 percent of approximately 3.9 million people. In comparison, the average population from 2006 to 2013 of employed males between 15 and 54 with Spanish citizenship is 7.9 million, according to estimates from the Active Population Survey conducted by the Instituto Nacional de Estadistica. Our additional selections on geography, industry, type of employment, and attachment to the labor market therefore

Table A.1: Summary Statistics

Variable	Units	Mean	Std. Dev	Min	Max
Daily earnings	Euros	73.41	93.60	0.15	37,042.03
Number of co-workers	Persons	601.16	1,895.15	1.00	22,077.00
Age	Years	35.02	7.48	16.00	51.92
Less than high school	Dummy	0.50	0.50	0.00	1.00
High school and some college	Dummy	0.32	0.47	0.00	1.00
College and above	Dummy	0.19	0.39	0.00	1.00
Days under contract, current month	Days	29.92	3.15	1.00	31.00
Firm tenure	Years	5.25	5.39	0.00	33.36
Experience	Years	11.80	6.89	0.00	37.11
Experience in two biggest cities	Years	4.68	6.82	0.00	34.02
Experience in 3rd-5th biggest cities	Years	1.08	3.62	0.00	33.35
Experience outside 5 biggest cities	Years	4.47	6.39	0.00	33.42
Experience in current city	Years	9.44	6.71	0.003	34.02
Fixed contract	Dummy	0.27	0.44	0.00	1.00
Part-time contract	Dummy	0.08	0.28	0.00	1.00
Very-high-skilled occupation	Dummy	0.08	0.28	0.00	1.00
High-skilled occupation	Dummy	0.12	0.32	0.00	1.00
Medium-high-skilled occupation	Dummy	0.23	0.42	0.00	1.00
Medium-low-skilled occupation	Dummy	0.46	0.50	0.00	1.00
Low-skilled occupation	Dummy	0.11	0.31	0.00	1.00
Observations	7,308,794				

cludes the mean, standard deviation, minimum and maximum. Individuals in the sample are relatively young relative to the overall Spanish active population, with an average age of 35 years old. On average, they have a tenure of 5.25 years with their current employers and 11.80 years of employment experience.

It may at first seem surprising that with an average age of 35 years old, the average number of years of employment experience is only 11.80. Especially so given that 60 percent of the population did not graduate from college and therefore entered the labor market at a relatively young age. Indeed, this implies that workers spent an average of 5 years of non-employment since finishing formal education. This is consistent with Spain's high youth unemployment rates in the decades preceding our sample. Youth unemployment in Spain was 40 percent in 1996. It decreased steadily up to 2008, when it reached 20 percent. After the recession, it shot up to its 55 percent peak around 2013, when it finally started decreasing again. In 2010, youth unemployment reached 30 percent, still far from the pre-2008 levels. In this context, five years of non-employment does not seem excessive.

To test how representative our sample is relative to the Spanish active population, we compare it to the EU Labor Force Survey (LFS) conducted by Eurostat. We select the LFS sample to be as similar as ours as possible, given the available characteristics. We keep only males, from 15 to 54, born in Spain,

further reduced the population of reference by about 50 percent. These selections were intended to construct a sample of individuals whose earnings can be expected to behave according to a similar econometric model, but a word of caution is in order when extrapolating the results to the Spanish population, or populations who are very different from the population of reference.

Table A.2: Summary Statistics from EU Labor Force Survey

Variable	Units	Mean	Std. Dev	Min	Max
Age, median age from 4 bins	Years	35.68	10.61	15.00	54.00
Less than high school	Dummy	0.46	0.50	0.00	1,00
High school and equivalent	Dummy	0.23	0.42	0.00	1.00
Some college and above	Dummy	0.28	0.45	0.00	1.00
Tenure	Years	10.47	9.18	0.00	41.00
Fixed contract	Dummy	0.42	0.49	0.00	1.00
Part-time contract	Dummy	0.03	0.17	0.00	1.00
Observations	25,974				

who are not employed in the primary sector. The summary statistics for this data are presented in Table A.2. There are some differences between the data sources. For instance, the information on age in the LFS is given by three age bins: 15 to 14, 25 to 39, and 40 to 54. Recall, that our sample only includes individuals under the age of 52 since they are the ones for which we can track the whole labor history. In order to compute the average age, we use the median age in each bin. Overall, our sample is very comparable to the one in the EU-LFS, at least in the dimensions that we observe. There are small differences in education. However, the education categories are not identical since in our sample "some college" is included in the middle-skilled category, while it is in the high-skilled category for the EU-LFS. In our sample, part-time contracts seem a bit more common than in the EU-LFS.

The largest difference is in tenure, which is twice as high in the LFS compared to our sample. This could be driven by the selection of our sample that excluded for instance public employees. Moreover, it is worth noting that the best variable to proxy for tenure in the LFS measures the number of years since a worker was first employed by their current employer. In contrast, our measure of tenure counts the number of years continuously employed by the current employer. These two measures could differ if there is discontinuous involvement with the same employer.

A.3 Firm and Establishment Co-workers

This section explores whether establishment size or firm size seems more relevant to estimate the city size co-worker premium and the co-worker earnings premium. To examine this, we first regress the log of the number of co-workers at the establishment level for a worker i on city fixed effects γ_c and the log of co-workers at the firm, over all its establishments.

$$\ln(\text{establishment coworkers}_i) = \alpha_n + \eta_t + \gamma_c + \beta \ln(\text{firm coworkers}_i) + \epsilon_i$$

We then regress the city fixed effects on log city size

$$\gamma_c = \alpha + \theta \ln(\text{city size}_c) + \epsilon_c$$

Table A.3: City Size Co-worker Premium: Establishments vs Firms

	(1) Ln Estab. Co-Workers	(2) City FE	(3) Ln Firm Co-Workers	(4) City FE
Ln City Size		0.103**		-0.020
Ln Estab. Co-Workers			1.089***	
Ln Firm Co-Workers	0.697***			
Time and Sector FE	Y		Y	
Observations	7,308,794	76	7,308,794	76
R^2	0.763	0.043	0.760	0.001

Note: column (1) reports the results from regressing log establishment workers on city, time, and sector fixed effects. Column (2) reports the results from regressing the city fixed effects from Column (1) on log city size. Column (3) reports the results from regressing log firm workers on city, time, and sector fixed effects, Column (4) reports the results from regressing the city fixed effects from Column (3) on log city size. City size is measured as the number of people within 10km of the average person, an establishment corresponds to a firm-province tax identifier. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013. $p<0.1$, ** $p<0.05$, ***$p<0.001$.

We interpret θ as the city size co-worker premium, controlling for firm size. Column 2 of table A.3 presents the estimated elasticity of establishment co-workers with respect to city size, controlling for firm co-workers, as well as the coefficient, β, on log firm co-workers. It is equal to 0.103, implying that given firm co-workers, workers in a city twice as large have on average 7.40 percent more co-workers in their establishment. Column 4 of table A.3 reports the city size co-worker premium at the firm, controlling for establishment co-workers. Given a number of co-workers in the establishment, there is no further correlation between city size and the number of co-workers at the firm level. For this reason, in the main analysis we use the establishment co-workers to measure the city size co-worker premium. However, we do not control for the number of co-workers at the firm. Since these two are correlated, the effect of changing the number of co-workers at the establishment includes as well the change in co-workers at the firm level. This suggests that, although both naturally move together, the number of co-workers at the establishment level rather than the firm level is a more important confounding factor for estimates of the city-size earnings premium. Thus, we perform our decomposition exercises using establishment co-workers.

B Additional Results

B.1 A Closer Look into Mover Regressions

Although the inclusion of worker fixed effects allows us to control for unobservable characteristics, it also requires a sample selection of movers only. Whenever we include worker fixed effects, our identification of city fixed effects is coming from workers who move across cities.

There are several reasons why the estimates might change as a result of including worker fixed effects. First, as intended, we could be controlling for unobserved characteristics of the worker such as

Table A.4: Co-worker Earnings Premium: Establishments vs Firms

	(1) Ln Earn.	(2) Ln Earn.	(3) Ln Earn.
Ln Estab. Co-Workers	0.049***	0.026***	0.004***
Ln Firm Co-Workers	0.018***	0.021***	0.022***
Worker FE	N	N	Y
Controls	N	Y	Y
Observations	7,308,794	7,308,794	7,308,794
R^2	0.216	0.510	0.062

Note: this table reports the results from regressing log earnings on city fixed effects and a series of controls, and then regressing the city fixed effects on log city size. City size is the number of people living within 10km of the average person. Controls include education, occupational categories, industry and time fixed effects, and type of contract. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013. $p<0.1$, ** $p<0.05$, ***$p<0.001$.

innate ability. Second, since we are selecting workers based on whether they moved or not, it may be that workers who move are not representative of the whole population and they may not experience the same earnings premium as non-movers. If workers only move in response to an attractive job offer, the increase in earnings as a result of the move may be higher than what we would observe if any person were to move at random to a large city. If on the contrary, workers move for other reasons and need some time to find a good job offer, the increase in earnings may be lower than the average difference in earnings across cities. There could also be learning effects as emphasized in De la Roca and Puga (2017) so that as workers stay in a large city, they accumulate valuable experience that leads to faster growth in earnings relative to a smaller city.

First, we test whether movers are representative of the whole population. We compute the city-size earnings premium for movers by running the cross-sectional regression not including worker fixed effects, but only for those workers that move at some point in our sample. The results are included in Columns 2 of Table B.1 while Column 1 presents the comparable results for the full sample. Reducing the sample to only movers has a small positive effect on the cross-sectional coefficient. For movers, the elasticity between earnings and city size is 0.049 as compared to 0.047 in the whole population. Therefore, it doesn't seem that workers who move at some point are much different than the general population.

Finally, we look a little deeper into moves across cities and how they relate to moves across establishment sizes. In Table B.2, we look at the transition matrix between establishment size categories for workers who move between small and large cities. We compare the transition matrix between establishment size categories observed in the data to what would be expected if the moves across establishment size categories were random, given the differences in establishment size distributions across city sizes (i.e. suppose the worker were to match to a random establishment size category based on the share of employment accounted for by establishments of that size). We find that, relative to random moves, workers tend to move within an establishment size category (the diagonal elements of the matrix are mostly larger in the data than if the moves were random). This indicates that there is some degree of

Table B.1: Selection of Movers and Worker Fixed Effects

	(1)	(2)
	Ln Earnings City FEs from Step 1	
	Full Sample	Movers Only
Ln City Size	0.047***	0.049***
Worker Fixed Effects	N	N
Controls	Y	Y
Observations	7,308,794	1,133,848

Note: * p<0.1; ** p<0.05, ***p<0.01. This table reports the results from regressing log earnings and log co-workers on city fixed effects and a series of controls, and then regressing the city fixed effects on log city size selecting only movers. City size is the number of people living within 10km of the average person. Controls include education, occupational categories, industry and time fixed effects, and type of contract. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.

sorting of workers to establishment sizes. Workers who work at a large establishment and move from a small to large city are just as likely to work for a large establishment when they arrive in the big city. However, we do not necessarily see evidence of selection; The transitions of workers from small cities to large cities do not appear to be more directed towards large establishments than if the moves were random. If anything they are slightly less likely to work at a large establishment than if they had received a random job offer.

B.2 Heterogeneity in the Co-worker Earnings Premium Across Cities

Moving to an establishment with more co-workers is associated with large earnings gains. However, it is possible that these gains are not the same across all cities. We calculate the within-city co-worker earnings premium, namely the expected premium from increasing the number of co-workers conditional on staying in the same city, and we show that it is decreasing in city size. This novel fact has important implications. In decomposing the city-size earnings premium, our goal is to understand what share of the city-size premium is driven by a contemporaneous move to a larger establishment. The fact that the within-city co-worker earnings premium is smaller in large cities means that the expected effect of moving from a small establishment in a small city to a large establishment in a large city will be smaller than the naive estimate of combining the average co-worker earnings premium and the average city-size co-worker premium. Second, the differences across cities in the co-worker earnings premium has important implications for the medium-term earnings gains from living in a large city. Climbing the establishment-size ladder will have smaller effects in a large city suggesting that the medium-term gains from learning documented by De la Roca and Puga (2017) are less likely to manifest by faster transitions to larger establishments. We discuss the dynamic implications further in section 4.2.

A final implication of the fact that the co-worker earnings premium is smaller in large cities is that it provides supporting evidence that firms in large cities have less monopsony power than firms in small cities. This is consistent with the theory of firm sorting proposed by Manning (2010). In his theory,

Table B.2: Non-random Moves across Establishment Size Categories

	Moving to:	Large Estab.	Middle Estab.	Small Estab.
		Random		
Moving from:	Large Estab.	14%	7%	8%
	Middle Estab.	14%	7%	8%
	Small Estab.	20%	10%	12%
		Data		
Moving from:	Large Estab.	13%	7%	6%
	Middle Estab.	13%	10%	9%
	Small Estab.	16%	13%	13%

Note: this table reports the percentage of people who move across city sizes that also move across establishment sizes and compares it to the percentages if the moves across firm sizes were random. A large city is defined as one of the three largest cities, that is, Madrid, Barcelona or Valencia, and a small city refers to a not city that is note in the top 5 largest cities. A small establishment is an establishment with fewer than 20 employees, a medium establishment is an establishment that has between 20 and 100 employees and a large establishment is an establishment with more than 100 employees. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013. $p<0.1$, ** $p<0.05$, ***$p<0.001$.

large firms sort to large cities because they face a higher elasticity of labor supply in large cities, i.e. they have less monopsony power. This means that in order to grow large, they do not need to raise wages as much in a large city relative to a small city. Thus, the relationship between establishment size and earnings is weaker in large cities.

In order to document the relationship between the within-city co-worker premium and city size, we again follow a two-step procedure. First, we run a regression similar to equation 3.1, but this time allowing the coefficient on log number of co-workers to vary across cities. Specifically, we run the regression

$$\ln(w_{it}) = \alpha_{c(i,t)} + \delta_t + \mu_i + \beta_{c(i,t)} \ln(\text{co-workers}_{it}) + x'_{it}\psi + \epsilon_{it}, \tag{B.1}$$

where $c(i,t)$ is the city where individual i lives at time t, $\alpha_{c(i,t)}$ is the corresponding city fixed effect, δ_t is a month-year fixed effect, μ_i is an individual fixed effect, x_{it} is a vector of characteristics of worker i at time t which include education, occupation, sector, experience, tenure, and type of contract; and ϵ_{it} is the residual earnings. Next, we regress the coefficient on log co-workers, β_c, on log city size

$$\beta_c = \gamma \ln(\text{city size}_c) + u_c. \tag{B.2}$$

We report the results of these regressions in table B.3. Columns 2 and 4 give the relationship between the within-city co-worker earnings premium and city size. Without controlling for worker fixed effects, the relationship is negative but statistically insignificant at the 10% level. After adding worker fixed effects, the relationship becomes significant at the 1% level. Controlling for worker fixed effects, the within-city co-worker earnings premium is identified off of workers who move across establishment sizes within a city thus controlling for the possibility that within cities, workers of different abilities are sorting to different establishments. The fact that the estimate of the within-city co-worker premium declines more for large cities once we control for worker fixed effects suggests that sorting plays a larger

Table B.3: Co-workers Earnings Premium and City Size

	(1)	(3)	(4)	(6)
	Ln. Earn	β_c	Ln Earn.	β_c
Ln City Size		-0.0041		-0.0058
		(0.0027)		(0.0021)***
City FE	Y		Y	
Worker Fixed Effects	N		Y	
Controls	N		Y	
N	7,308,794	76	7,308,794	76
R^2	0.2471	0.0252	0.390	0.0377

Note: this table reports the results from regressing log earnings on log establishment workers. Controls include experience, tenure, education, occupational categories, time and sector fixed effects, and dummies for part time and fixed term contracts. Data Source: An establishment corresponds to a firm-province tax identifier. Clustering is implemented at the person level. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013. $p<0.1$, ** $p<0.05$, ***$p<0.001$.

role in large cities. This is consistent with the evidence presented by Dauth et al. (2019) suggesting that sorting of high skilled individuals to large establishments is more important in large cities.

The within-city co-worker earnings premium is 0.40 ($= 0.58 \times \ln(2)$) percentage points to a significant difference in the co-worker earnings premium between large and small cities. In Utrera, the smallest city in our sample, the elasticity between earnings and city size is 0.053, while in Madrid the elasticity is 0.022, less than half the size of the elasticity in Utrera. Figure 3.1 presents the relationship between the within-city co-worker earnings premium and city size graphically. Note that while there is a wide range of these premiums within small cities, for large cities, the within-city co-worker premium hovers around 2.5 percent, similar to the economy wide average estimated in panel 2, column 3 of table 3.1.

B.3 Number of Co-Workers and the Medium-Term City-Size Earnings Premium

In this section, we delve deeper into the mechanisms through which establishment size affects the earnings premium of large cities in the medium-term. The source of the short-term earnings premium is straightforward. When workers move into larger cities, they also move to larger and better-paying establishments, and as a result they receive an earnings premium.

The source of the medium-term gains however is more complicated since it could arise from different mechanisms. In order to understand the role of establishment size, it is useful to first divide the mechanisms that lead to medium-term earnings gains in two types. First, those related to the fact that the experience accumulated in large cities is more valuable anywhere. Second, those related to the fact that experience accumulated anywhere is more valuable when the worker is in a large city.

We did not distinguish between these mechanisms until now because we were comparing the earnings of two identical workers who take two paths: working in a large city or in a small city for 9.4 years. The short-term earnings premium is the difference in their earnings the moment they start working, while

medium-term earnings gains would be the difference in their earnings after the 9.4 years. If we want to decompose this difference into the two mechanisms above, we would look at the difference earnings that would remain if these two identical workers locate back in the same city after the 9.4 years. This difference in earnings would come from the fact that experience accumulated in large cities is more valuable.

Recall that we did estimate both separately. In equation 4.1 we estimate coefficients on the experience accumulated in different bins of cities allowing them to differ depending on the location of the worker.

The number of co-workers could play a role for both types of channels. There are two channels that we can test with our data. First, the number of co-workers would explain why experience accumulated in large cities is more valuable anywhere. If the number of co-workers not only increases at the time of the move, but it grows faster in larger cities, therefore as time passes the difference between living in a small or a large city increases through the growth in the number of co-workers. We quantify this channel in the first subsection B.3.1.

Second, establishment size could also play a role in making experience accumulated anywhere be more valuable in large cities. If experience accumulated anywhere is more valuable when working in larger establishments, since workers are more likely to work in larger establishments these could explain part of the reason why the coefficient on experience is larger when the workers are located in larger cities. We test for the quantitative importance of this channel in the second subsection B.3.2.

There is another channel that we cannot test. Since experience accumulated in larger cities is also experience accumulated with more co-workers, it is possible that the number of co-workers throughout the labor history explains part of the value of experience in large cities. Unfortunately, we cannot test this channel since we do not observe the number of co-workers throughout the labor history of individuals while we do observe the cities where the experience was accumulated.

B.3.1 The City-Size Co-worker Premium in the Medium-Term.

The goal of this subsection is to understand whether the number of co-workers not only increases with city size at the time of the move (short-term effect), but whether it also grows faster in larger cities (medium-term effect). We run regression 4.1 with log co-workers as the dependent variable instead of log earnings. The results are presented in Table B.4.

We find that the elasticity of the number of co-workers with respect to city size is 0.2928 at the time of move, and 0.3228 in the medium-term. This means that a worker with no experience who decides to move to a city twice the size will experience an initial increase of 22.5 percent on the number of coworkers at the time of the move. Moreover, if the worker stays in the larger city for 9.4 years, at that point, he will have 25.1 percent more co-workers compared to staying in the smaller city for the 9.4 years. The medium-term gain is only a 2.4 percent additional increase in the number of co-workers. Therefore, most of the gain in the number of co-workers is realized upon moving to a large city and establishment size plays a relatively small role in the medium-term earnings gain.

Table B.4: Short- and Medium-term City-size Co-worker Premium

	(1) 1st Step: Ln Co-workers	(2) 2nd Step, Short-term: City FE, from 1st Step	(3) 2nd Step, Medium-term: City FE plus City-Specific Experience from 1st Step
Ln City Size		0.2928	0.3228
		(0.0431)***	(0.0500)***
City-Specific Experience	Y		
City FE	Y		
Worker FE	Y		
Controls	Y		
Observations	7,308,794	76	76
R^2	0.2512	0.4202	0.4561

Note: column (1) reports the results of the first step, we regressed log co-workers on city fixed effects and a series of controls. Column (2) reports the short-term results of the second step, consisting in regressing the city fixed effects on log city size. Column (3) reports the medium-term results of the second step, consisting in regressing the city fixed effects on log city size augmented by the effect of average experience in the city, on city size. City size is measured as the number of people living within 10km of the average person. Controls include occupational categories, industry and time fixed effects, and type of contract. In addition, we control always for month and sector fixed effects. Clustering is implemented at the person level. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013. $p<0.1$, ** $p<0.05$, ***$p<0.001$.

B.3.2 Number of Co-Workers and the Value of Experience.

In this section, we test whether experience accumulated anywhere is more valuable if workers have more co-workers. If this is the case, it could explain part of the reason why experience accumulated anywhere is more valuable in larger cities, which is part of the medium-term earnings gains.

In order to answer this question, we run regression 4.1 and include as an additional control the interaction between experience and the current number of co-workers. Including this control may change the estimated coefficient on the value of experience when workers are currently living in a large city since living in a large city is correlated with the number of co-workers. The results are presented in Table B.5.

We find that the elasticity of earnings with respect to city size for a worker with no previous work experience and keeping the number of co-workers constant is 0.0190 at the time of the move and 0.0362 after 9.4 years of living in a city twice as large. Recall that the elasticities controlling for numbers of co-workers but without controlling for the fact that experience may be valued differently depending on the number of coworkers were 0.0189 in the short-term and 0.0355 in the medium-term. The change in both the short- and the medium-term premiums are small and not significant. This is because the value of experience does not depend strongly on the current number of co-workers. Therefore, this mechanism is not the main driver for the role of establishment size on the medium-term city-size earnings premium.

To conclude, the current number of co-workers explains little of the medium-term city-size earnings premium for two reasons. First, because the number of co-workers does not grow much faster in

Table B.5: Value of City-Specific Experience Depending on Number of Co-Workers

	(1) 1st Step: Ln Earnings	(2) 2nd Step, Short-term: City FE, from 1st Step	(3) 2nd Step, Medium-term: City FE plus City-Specific Experience from 1st Step
Ln City Size		0.0190	0.0362
		(0.0047)***	(0.0093)***
Ln Co-workers	0.0255		
	(0.0009)***		
City-Specific Experience	Y		
City-Specific Experience × Ln Co-workers	Y		
City FE	Y		
Worker FE	Y		
Controls	Y		
Observations	7,308,794	76	76
R^2	0.4220	0.1354	0.3043

Note: column (1) reports the results of the first step, we regressed log earnings on city fixed effects,log number of co-workers, city-specific experience, experience interacted with log number of co-workers, and a series of controls. Column (2) reports the short-term results of the second step, consisting in regressing the city fixed effects on log city size. Column (3) reports the medium-term results of the second step, consisting in regressing the city fixed effects on log city size augmented by the effect of average experience in the city, on city size. City size is measured as the number of people living within 10km of the average person. Controls include occupational categories, industry and time fixed effects, and type of contract. In addition, we control always for month and sector fixed effects. Clustering is implemented at the person level. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013. $p<0.1$, ** $p<0.05$, ***$p<0.001$.

larger cities coupled with the lower co-worker earnings premium in large cities. Second, because the current number of co-workers does not affect the value of experience significantly. However, there is still a potential role for the history of the number of co-workers if experience accumulated in larger establishments is more valuable. Unfortunately, this cannot be tested with the data used in this paper.