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

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Preliminary, please do not circulate.

Abstract

When workers move to a larger city, they tend to experience an increase in earnings. But they also tend to move to larger and better-paying establishments. This paper studies the role of establishment-size composition in explaining the city-size earnings premium. Using administrative data from Spain, we first document a strong positive correlation between city size and establishment size, measured as the number of co-workers. The establishment size for a typical worker is 33 percent larger in a city with twice the population density, even after controlling for worker fixed effects and other observable characteristics. We then decompose the city-size earnings premium into two components: the increase in earnings explained by the increase in establishment size and the within establishment-size premium. We find that 30.8 percent of the short-term gains of moving to a city twice larger can be explained by a transition to a better-paying larger establishment. In contrast, only 5.0 percent of the medium-term gains of accumulating experience in a large city can be attributed to a faster transition to larger establishments. The small contribution to the medium-term gains is due to two facts: first, in large cities establishment size only grows slightly faster than in smaller cities; second, the relationship between earnings and establishment size is weaker in larger cities. Our results indicate that the role of establishment size composition is fundamental for understanding the short-term gains of moving to a larger city but much less so for explaining the medium-term gains.

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1 Introduction

Both large firms and large cities are known to offer workers an earnings premium. A less recognized fact is that large cities host larger establishments. Hence, when workers move to larger cities, part of the increase in earnings they experience will be explained by the fact that they transition to better-paying larger establishments. In this paper, we evaluate how much of the city-size earnings premium is due to establishment-size composition. Using rich administrative data on worker-level earnings histories in Spain, we find that on average 30.8 percent of the short-term earnings gain and 5.0 percent of the medium-term gain from moving to a larger citiy can be attributed to the transition to larger establishments.

Our results shed light on the drivers of the city-size earnings premium by looking at the role of establishment size. If most of the earnings gains obtained from moving to a larger city were accounted for by differences in the composition of establishment sizes, explaining the presence of larger establishments in large cities would be pivotal for understanding the city-size earnings premium. If, on the other hand, very little of the city-size earnings premium can be accounted for by establishment-size composition, this would point towards a mechanism that provides an advantage to workers and firms in larger cities regardless of establishment size. Our findings suggest that it is necessary to think of a mechanism that works on both margins for the short-term gains. Since the medium-term earnings gains in large cities are not driven by moves to larger establishments, they are likely to be driven by mechanisms that operate regardless of establishment-size transitions, such as learning, as opposed to theories that consider differences in the job ladder across cities.

We start by documenting three stylized facts. First, we establish what we call the "co-worker earnings premium"[1], namely that a transition to an establishment with more co-workers is associated with an increase in earnings. Controlling for observable and unobservable worker characteristics, we find that doubling the number of co-workers is associated with 2.7 percent higher earnings. 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. Second, we document the well-known "city-size earnings premium", and estimate that moving to a city twice larger is associated with a 2.3 percent increase in earnings, in line with the findings of De la Roca and Puga (2017) using the same data. Third, we compute 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 33 percent more co-workers.

[1] 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 the correlation between 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 correlation between a worker's pay and the number of co-workers.

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 2.3 percent increase in earnings from moving to a city twice as large, 39.1 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. In order to do so, 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 2.6 percent[2]. If we further control for the number of co-workers, we find that the increase in earnings falls to 1.8 percent. Therefore, the transition to larger establishments accounts for 30.8 percent of the short-term city-size earnings premium.

Finally, we explore the role of transitions between establishments of different sizes in explaining the dynamic earnings gains offered by large cities. These dynamic gains were first documented by De la Roca and Puga (2017), and reflect the additional earnings gains accruing to workers as they acquire additional years of experience in a large city. We find that after 8.9 years of experience in a city twice larger, which is the average experience in our sample, workers benefit from an additional 1.8 percent increase in earnings in line with the findings in De la Roca and Puga (2017). These dynamic gains could be due to a faster transition to larger establishments in large cities or 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 smaller in large cities. This fact dampens the contribution of the faster growth in the number of co-workers leading to a small dynamic gain from establishment size. Only 5.0 percent of the dynamic earnings gains in larger cities can be attributed to a faster growth in the number of co-workers.

This paper contributes to several strands of the existing literature. It is most closely related to Manning (2010), who was the first to provide a careful study of the relationship between establishment size and city size using establishment-level data from the United States and Great Britain. We complement his findings by showing that establishments are systematically larger in large cities in Spain too even after controlling for observable and unobservable worker heterogeneity. Furthermore, to the best of our knowledge, we are the first to document the relationship between the within-city co-worker earnings premium and city size. When put to the forefront,

[2]Notice that the short-term city-size earnings premium is 0.3 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. People moving to large cities tend to be younger and have little experience in large cities. On the contrary, people who move to smaller cities tend to have some experience in larger cities and their earnings fall a bit less.

these empirical regularities will be useful to disentangle the contribution of different sources of agglomeration.

We also contribute to the literature on firm sorting across city sizes which requires some complementarity between establishment and city size (Gaubert (2018); Duranton and Puga (2001); Brinkman et al. (2012); Combes et al. (2012); Manning (2010)). The robustness of the city-size co-worker premium provides evidence for this complementarity. Further, the fact that the co-worker earnings premium is smaller in large cities is consistent with the mechanism in Manning (2010), who argues that firms sort based on differences on monopsony power across cities. With lower monopsony power firms face a more elastic labor supply curve and do not need to raise wages as much to attract workers. This generates a weaker relationship between earnings and establishment size in large cities.

Gauging the relative importance of establishment size and city-effects in the city-size earnings premium matters because they are typically associated with different mechanisms, and largely separate literatures. On the one hand, this paper is related to the recent literature employing rich micro-level data to understand the role of firm size in determining earnings (Bloom et al. (2019); Mueller et al. (2017))[3]. On the other hand, the paper echoes a vast literature exploring the sources of the city-size earnings premium including sorting of more productive workers to large cities, local agglomeration forces, knowledge spillovers and labor pooling (Eeckhout et al. (2014); Diamond (2016); Behrens et al. (2014); Giannone (2018); De la Roca et al. (2014); Combes et al. (2008); Davis and Dingel (2014)). In principle, given the positive correlation between city size and establishment size, either of the two size premia could be driving the other one. Our contribution is to quantify their relative importance and provide new evidence to be contrasted against some of the mechanisms proposed in the literature.

Finally, our results also connect to several theories advanced to explain the residual city-size earnings premium remaining once sorting is controlled for. In particular, the limited role of establishment size transitions in the dynamic gains favors stories of learning as in Davis and Dingel (2012). Moreover, the recent study by Dauth et al. (2019) seems to support the interpretation of stronger assortative matching between workers and establishments in large cities. We find that controlling for sorting between workers and establishments decreases the relationship between establishment size and earnings in large cities more than small cities. This is consistent with a more important role for assortative matching in large cities. Finally, Eckert et al. (2019) find that part of the earnings premium for experience accumulated in large cities is associated to experience in high-paying establishments using quasi-experimental data for refugees in Denmark. In our data set, although we observe the whole history of locations, we do not observe the history of the number of co-workers. Instead, we focus on quantifying the dynamic effect coming from a faster growth in the number of co-workers in larger cities.

[3]This, in turn, echoes an older literature on the firm size earning premium including papers by Burdett and Mortensen (1998); Mellow (1982); Brown and Medoff (1989); Bayard and Troske (1999).

The rest of the paper is organized as follows. Section 2 describes the Spanish administrative data. Section 3 documents the new stylized facts on establishment size earnings premium, the establishment size earnings premium 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 and compares the contribution of establishment-size composition for short-term and medium-term gains of working in larger cities. Section 5 concludes.

2 Data Description

We use data from the Muestra Continua de Vidas Laborales (MCVL). This data is collected by the Social Security Administration in Spain and it consists of a panel that follows 4 percent of the Spanish population for every year between 2004 and 2013. Individuals are part of the sample in a given year if two conditions hold. First, their National ID number is selected as part of the 4 percent random sample of IDs. Second, they have a relation with the Social Security Administration that year, either by paying taxes on their labor earnings or receiving benefits such as unemployment or pensions.

Although the data was only collected starting in 2004, we observe the whole labor history of people in the sample, so that if an individual in the 4 percent sample worked in 2004 we are able not only to observe information for 2004 but also for their whole history of interactions with the Social Security Administration prior to that year. Accessing the labor history allows us to construct very detailed information on their work experience and the number of years they spent in large cities. Being able to observe their whole labor history is key for our analysis.

We use data for years 2006 to 2013 since the year 2005 is no longer made available due to data errors. This period includes the years of the financial crises in Spain which started in 2008, as well as the housing boom leading up to it. Monthly fixed effects will be used in most of the estimation to control for such national cycles. To the extent that the boom and bust period might have affected larger cities systematically different, it will affect our estimates of the city-size premium. Therefore, the city-size premium should be interpreted as particular to this economic period in Spain.

2.1 Data Definitions and Sample Selection

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, 161,474 persons, and 7,727,861 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.[4].

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

[4]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.

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.2 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.2 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).

Sample selection. The final sample includes working-age males born in Spain who are employed, excluding public employees, workers under apprenticeship contracts, co-op workers, and employees in agriculture, fishing, forestry, extractive industries, public administration, education, health services and international organizations. The reason to not include women is that female labor force participation 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. We also exclude workers whose contracts specify discontinuous involvement. Finally, the sample only includes individuals who worked for the equivalent of 30 days in a calendar year.

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.

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

This section documents several stylized facts using administrative data from Spain for the years 2006 to 2013. Two of these facts have been widely documented in a variety of settings: the

city-size earnings premium, namely the positive association between earnings and city size, and the co-worker earnings premium, corresponding to the positive association between earnings and the number of co-workers.

Next, we document several facts about the city-size and co-worker premium that have not been widely documented in the literature. First, we show that the co-worker earnings premium is not constant across cities. Within Utrera, the smallest city in Spain, moving to an establishment twice as large is associated with a 5.29% earnings premium, while in Madrid a worker who moves to an establishment twice as large can only expect a premium of 2.21%. The fact that the co-worker earnings premium is decreasing with city size is a novel fact we introduce to the literature. The final fact we document is the city-size co-worker premium, that is, the increase in the number of co-workers associated with living in a larger city. This fact has received less attention in the literature with the exception of Manning (2010), who finds that establishments have more workers in large cities in the U.S. and U.K.

Finally, in section 3.4, we present a series of robustness checks that examines the effect of adding worker fixed effects to our regressions. When we add worker fixed effects, in addition to controlling for unobserved heterogeneity, we are also identifying the city fixed effects off of the sample of workers who ever move across cities. The goal of these robustness exercises is to determine if the sample of movers is systematically different from workers who never move. We find limited differences between the two groups and are reassured that the change in estimates upon adding fixed effects is indeed due to controlling for for unobserved heterogeneity and not to sample selection effects.

3.1 City-size Earnings Premium

3.1.1 Two step methodology

Before documenting the three stylized facts, we briefly discuss the methodology. In order to test the correlation between city size and earnings or the number of co-workers, 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. 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. 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. The intuition for estimating the effect in the two steps is the following. If the regression is done in one-step, the error term in the second step will be part of the one-step residual and could contain omitted variables that are correlated with city size. To fix notation, first we 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:

$$ln\left(w_{it}\right) = \alpha_{c(i,t)} + \delta_t + \mu_i + x_{it}^{'}\psi + \epsilon_{it}, \tag{3.1}$$

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 include education, occupation, sector, experience, tenure, and type of contract; and ϵ_{it} is the residual earnings. For reference, section A.1 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:

$$\alpha_c = \beta ln\left(city\, size_c\right) + u_c. \tag{3.2}$$

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.

3.1.2 City-size Earnings Premium Results

We first document the correlation between city size and earnings in the data. This exercise and the results are similar to those of De la Roca and Puga (2017). The results are summarized in Table 3.1. Workers in cities with twice the population have on average 8.5 percent higher earnings. 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 these characteristics, workers in cities with twice the population have on average 4.6 percent higher earnings, that is, almost half of the percentage difference in earnings can be explained by observable characteristics.

Finally, we control for unobserved worker characteristics by including worker fixed effects. A worker moving to a city with twice the size should expect an average 2.3 percent increase in earnings. The earnings premium is 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 in 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

Table 3.1: City Size Earnings Premium

	Ln Earn.	City FE	Ln Earn.	City FE	Ln Earn.	City FE
	(1)	(2)	(3)	(4)	(5)	(6)
Ln City Size		0.085		0.046		0.023
		(0.0130)***		(0.0081)***		(0.0050)***
City FE	Y		Y		Y	
Worker FE	N		N		Y	
Controls	N		Y		Y	
N	7,727,861	76	7,727,861	76	7,727,861	76
R^2	0.072	0.287	0.485	0.237	0.375	0.166

** p<0.1; ** p<0.05, ***p<0.01*

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. Clustering is implemented at the person level. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.

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 ever move across cities. Therefore, once we control for worker fixed effects, we are identifying the city-size earnings premium using only workers who move across cities, these movers might be systematically different from workers who never move. Subsection 3.4 explores which factor is more important and finds that the first effect dominates.

3.2 Co-worker Earnings Premium

Next, we document the correlation between the number of co-workers and earnings in the data. Table 3.2 summarizes the results from regressing log earnings on the log number of co-workers. Workers with twice as many co-workers have, on average, 8.0 percent higher earnings. Part of this effect could be due to workers sorting across establishments. Controlling for a broad set of observable worker characteristics such as experience, tenure, education, occupation, reduces the effect of doubling the number of co-workers to 4.9 percent higher earnings. This decrease is evidence that there is sorting of higher earners to establishments with more co-workers. Since we have access to a panel of workers, we can further control for worker fixed effects and evaluate the relevance of unobserved characteristics. The coefficient on log co-workers captures the average change in earnings for workers who move across establishment sizes. A worker moving to an establishment with twice as many co-workers should expect a 2.7 percent increase in their earnings. We refer to this increase as the co-worker earnings premium.

It is also worth noting that the city size earnings premium (2.3 percent) is close in magnitude to the co-worker earnings premium (2.7 percent). Implying that a worker switching to an

Table 3.2: Co-worker Earnings Premium

	Ln Earn.	Ln Earn.	Ln Earn.
	(1)	(2)	(3)
Ln Co-workers	0.080	0.049	0.027
	(0.0006)***	(0.0005)***	(0.0005)***
City FE	N	N	N
Worker Fixed Effects	N	N	Y
Controls	N	Y	Y
N	7,019,750	7,019,750	7,019,750
R^2	0.108	0.502	0.385

** p<0.1; ** p<0.05, ***p<0.01*

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.

employer with twice as many co-workers should expect a similar increase in earnings as if they were moving to a city with twice the size.

3.2.1 Co-worker Earnings Premium and City Size

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. In this section, 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 dynamic earnings gains from living in a large city. Climbing the establishment-size ladder will have smaller effects in a large city suggesting that the dynamic 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, 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

$$ln\left(w_{it}\right) = \alpha_{c(i,t)} + \delta_t + \mu_i + \beta_{c(i,t)} ln\left(coworkers_{it}\right) + x_{it}^{'}\psi + \epsilon_{it}, \tag{3.3}$$

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

$$\beta_c = \gamma ln\left(city\, size_c\right) + u_c. \tag{3.4}$$

We report the results of these regressions in table 3.3. 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 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 0.54 percentage points smaller in cities twice as large. In practice, this corresponds to a significant difference in the co-worker earnings premium between large and small cities. In Utrera, the smallest city in our sample, moving to an establishment twice as large is associated with a 5.29 percent earnings premium, while in Madrid a worker who moves to an establishment twice as large can only expect a premium of 2.21 percent. 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 premia 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 column 3 of table 3.2.

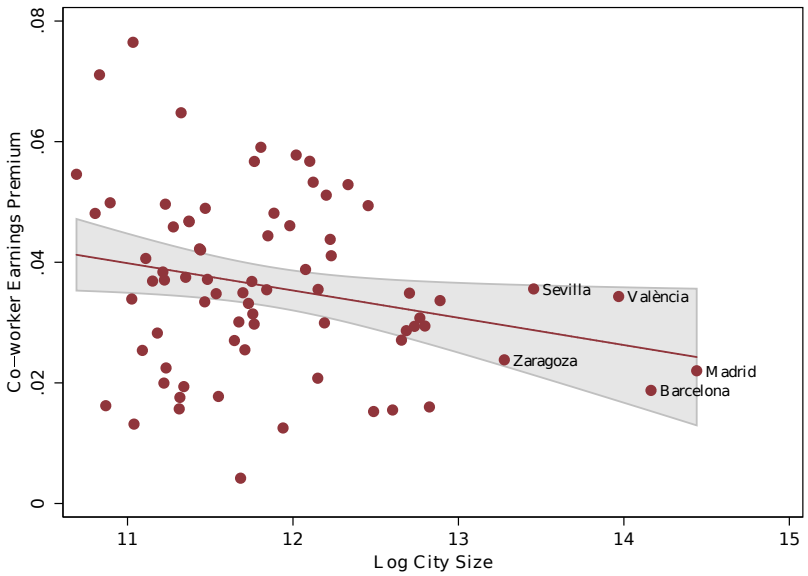
Table 3.3: Co-workers Earnings Premium and City Size

	Ln. Earn	β_c	Ln Earn.	β_c
	(1)	(3)	(4)	(6)
Ln City Size		-0.0031		-0.0054
		(0.0023)		(0.0020)***
City FE	Y		Y	
Worker Fixed Effects	N		Y	
Controls	N		Y	
N	7,019,750	76	7,019,750	76
R^2	0.5160	0.0210	0.387	0.0338

** p<0.1; ** p<0.05, ***p<0.01*

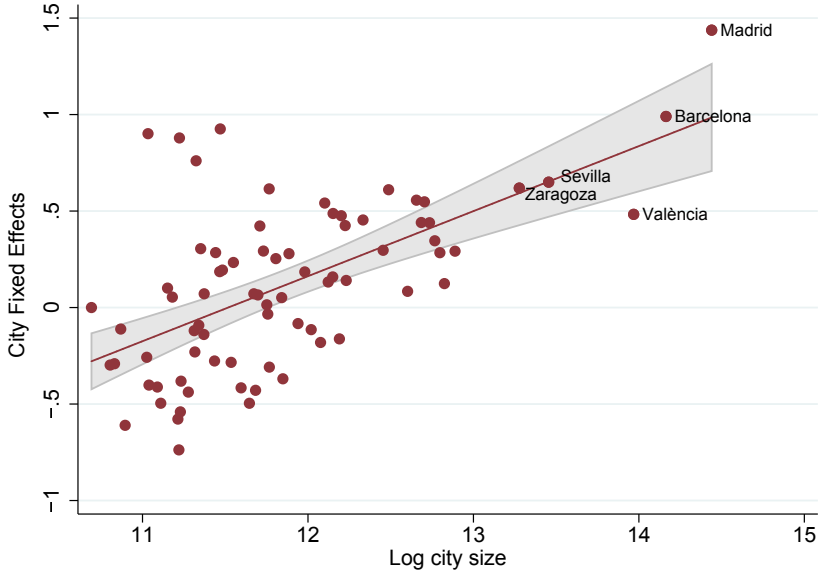
Note: this table reports the results from regressing log earnings on log establishment workers. Controls include experience, tenure, education, occupational categories, time and sector fixed effects, and dummies for part time and fixed term contracts. Data Source: An establishment corresponds to a firm-province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

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.

Figure 3.2: City Size Co-worker Premium



Note: This figure plots the city fixed effects on log city size, where the city fixed effects result from regressing log number of establishment workers on sector, time and city fixed effects. number of workers, and 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.

3.3 City Size Co-worker Premium

The third fact that we document is the positive correlation between the number of co-workers and city size. Figure 3.2 plots the city fixed effects from a regression of log co-workers, controlling for sector and time dummies, against city size. Workers in larger cities tend to have more co-workers, even controlling for sector composition. This positive correlation could arise either because the same worker would have more co-workers if they were to move to a larger city, or because workers are different across cities so that workers in larger cities may be more likely to work with more co-workers even if they moved out of the large city.

In order to explore whether workers that are more likely to have more co-workers select into larger cities, Table 3.4 reports the results of a regression of log co-workers on city fixed effects. The first two columns of the table correspond to the regression captured in Figure 3.2. Workers in cities with twice the size have on average 33.7 percent more co-workers. In the third and fourth column, we control for workers' education, occupation, and type of contract. Workers with similar characteristics but living in a city with twice the size have on average 32.1 percent more co-workers. Finally, controlling for worker fixed effects in the fifth and sixth columns we conclude that a worker moving to a city with twice the size should expect an average 33.2 percent increase in the number of co-workers. The estimates in the three specifications are very close, which suggests that sorting does not play an important role in explaining the city-size

Table 3.4: City Size Co-worker Premium

	Ln Co-work.	City FE	Ln Co-work.	City FE	Ln Co-work.	City FE
	(1)	(2)	(3)	(4)	(5)	(6)
Ln City Size		0.337		0.321		0.332
		(0.0493)***		(0.0480)***		(0.0465)***
City FE	Y		Y		Y	
Worker FE	N		N		Y	
Controls	N		Y		Y	
N	7,019,750	76	7,019,750	76	7,019,750	76
R^2	0.280	0.363	0.298	0.362	0.242	0.469

** p<0.1; ** p<0.05, ***p<0.01*

Note: This table reports the result of regressing log establishment workers on city fixed effects and a series of controls, and then regressing the city fixed effects 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. 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.

co-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.

Given the broad definition of establishments, which includes employment in a particular employer-province pair, it may not come as a surprise that the local firm employment is larger in larger cities. For example, a restaurant chain might have several small establishments in the province that in our data are grouped under one CCC. This is what we would expect in service or non-tradable sectors where employment is tightly linked to the local market size, but might be split into several small establishments. In order to test whether non-tradable sectors are driving most of the differences in establishment size, we follow our two-step methodology described in section 3.1.1 and for each sector regress the number of establishment workers on characteristics of the workers and city fixed effects. Then we regress the city fixed effects against log city size. Table 3.5 presents the elasticity of mean co-workers with respect to city size for different sectors. The larger elasticities are found in finance, communication, research and development, professional services and computer sectors, all highly tradable sectors while the least tradable sector such as personal services 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 driven by local market size.

3.4 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

Table 3.5: City Size Co-worker Premium by Sector

Tradables		Non-tradables	
Manufacturing	0.1474	Real Estate	-0.4101
	(0.1462)		(0.1433)***
Communication	0.5407	Rental Services	0.6483
	(0.1375)***		(0.3110)**
Professional Services	0.5979	Construction	0.2019
	(0.1257)***		(0.0659)***
Computer	0.7517	Retail and Wholesale	0.3355
	(0.1264)***		(0.0982)***
Research and Development	0.5074	Hotels	0.3551
	(0.1345)***		(0.1045)***
Finance	0.6513	Transportation	0.1041
	(0.1614)***		(0.1385)
		Entertainment	0.2281
			(0.1102)**
		Personal Services	-0.1431
			(0.1414)

** p<0.1; ** p<0.05, ***p<0.01*

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 10km 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.

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 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 earnigns 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. We will explore this last point in Section 4.

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 1 and 2 of Table 3.6. Reducing the sample to only movers has a small positive effect on the cross-sectional coefficient. Movers earn 4.9 percent higher

Table 3.6: Selection of Movers and Worker Fixed Effects

	Movers Only		Period Before		Period After	
	Ln Earn.	City FE	Ln Earn.	City FE	Ln Earn.	City FE
	(1)	(2)	(3)	(4)	(5)	(6)
Ln City Size		0.049***		0.046***		0.029***
Worker FE	N		N		N	
Controls	Y		Y		Y	
N	1,094,338	76	43,232	76	43,232	76
R^2	0.45	0.275	0.246	0.207	0.250	0.1276

** p<0.1; ** p<0.05, ***p<0.01*

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 selecting only movers, movers the period before the move, the period after and both the period before and after. 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.

wages in cities with twice the population as compared to 4.6 percent in the whole population. Therefore, it doesn't seem that workers who move at some point are much different than the general population.

Second, we check whether the smaller city-size earnings premium is coming from the fact that the worker fixed effects regression captures only the difference in wages for movers who have had less time to accumulate experience in their destination city. As documented by De la Roca and Puga (2017), workers in large cities accumulate human capital faster and see larger returns to experience. When we use fixed effects to control for unobserved heterogeneity, we are limiting our sample to movers who systematically have less experience in the large city. In order to check this, we run two cross-sectional regressions on the movers: one selecting only the period right before they move, and another selecting the period right after they move. The results from including only movers the period before they move are found in Columns 3 and 4 of Table 3.6. In the cross-section of movers before they move, the city-size premium is 4.6 percent, the same as in the cross-section with all the periods of movers and non-movers. Therefore, it doesn't seem that workers about to move look significantly different than the population as a whole. Next, we check whether movers look very different right after they have moved. In order to check this, Columns 5 and 6 of Table 3.6 select only period after a move. The city-size earnings premium in the cross-section of movers right after they have moved is only 2.9 percent, that is 1.6 percentage points lower than in the cross-section before a move. This suggests that the change in wages when a worker moves to a larger city is small at the time of moving and it grows over time as wages increase faster in larger cities.

These findings in the cross-section of movers are consistent with the potential faster accumulation of human capital in larger cities proposed by De la Roca and Puga (2017). The authors find

Table 3.7: City-specific Experience

	Log earn.	City FE	Log earn.	City FE	Log earn.	City FE	Medium-term
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ln City Size		0.046		0.033		0.026	0.044
		(0.0081)***		(0.0075)***		(0.0050)***	(0.0100)***
City FE	Y		Y		Y		
Worker FE	N		N		Y		
Controls	Y		Y		Y		
City Experience	N		Y		Y		
N	7,727,861	76	7,727,861	76	7,727,861	76	76
R^2	0.490	0.237	0.494	0.144	0.346	0.201	0.358

** p<0.1; ** p<0.05, ***p<0.01*

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. Clustering is implemented at the person level. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.

that city-specific experience helps account for a large part of the city-size earnings premium. We replicate their results in Table 3.7. Including city-specific experience decreases the cross-sectional city size premium from 4.6 to 3.3 percent, bringing it closer to the 2.6 percent premium in the regression with worker-fixed effects. This corresponds to 65 percent of the difference between the cross-sectional and the worker fixed effect earnings premium.

We follow De la Roca and Puga (2017) and predict earnings after 8.9 years in order to obtain the medium-term city-size earnings premium. Workers moving to a city with twice the size should expect 4.4 percent higher earnings after 8.9 years. This medium-term premium potentially encompasses not only learning effects from living in larger cities but also other dynamic effects, such as increases in earnings from workers potentially transitioning to larger establishments faster in larger cities. In the next section, we explore how much of the short- and medium-term city-size earnings premium can be explained by the workers transitioning to larger establishments.

4 Earnings and Co-worker Premia

In this section, we explore the role of the city-size co-worker premium, i.e. the fact that workers in larger cities tend to have more co-workers, in generating the city-size earnings premium. The goal is to compare earnings of similar workers with a similar number of co-workers in order to measure the effects of city size that do not work through differences in the number of co-workers. If a large fraction of the city-size earnings premium disappears when comparing workers with a similar number of co-workers, this would imply that in order to understand the city-size earnings premium, one must understand why the number of co-workers is higher in larger cities. If on the contrary, the earnings differences remain when comparing workers in similarly sized

Table 4.1: City Size Earnings Premium and Co-worker Earnings Premium

	Ln Earn.	City FE	Ln Earn.	City FE	Ln Earn.	City FE	Ln Earn.	City FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln City Size		0.046		0.033		0.023		0.014
		(0.0081)***		(0.0073)***		(0.0050)***		(0.0048)***
Ln Co-work.			0.044				0.027	
			(0.0005)***				(0.0005)***	
City FE	Y		Y		Y		Y	
Worker FE	N		N		Y		Y	
Controls	Y		Y		Y		Y	
N	7,727,861	76	7,019,750	76	7,727,861	76	7,019,750	76
R^2	0.485	0.237	0.514	0.152	0.375	0.166	0.3915	0.073

** p<0.1; ** p<0.05, ***p<0.01*

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. Clustering is implemented at the person level. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.

establishments, this would highlight the importance of city size effects that do not act through the number of co-workers.

4.1 Average Effects

We start by documenting how much of the city-size earnings premium can be attributed to the city-size co-worker premium, that is the fact that workers in large cities have, on average, more co-workers. Conversely, we also 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 two questions, we use the two-step methodology described in the previous section. In a first stage, we regress log earnings on city size fixed effects and workers characteristics, this time including number of co-workers. In the second stage, we regress the city fixed effects on log city size. As a result of this exercise, we obtain a new city-size earnings premium, this time controlling for number of co-workers, and a new co-worker earnings premium, this time controlling for city fixed effects. The results for this exercise are included in Table 4.1 and for comparison with the city-size earnings premium and co-worker earnings premium the reader can refer to Tables 3.1 and 3.2 respectively.

First, we analyze the change in the city-size earnings premium. We find that workers with similar characteristics and working with the same number of co-workers but living in a city with twice the size have 3.3 percent higher earnings. In comparison, workers with similar characteristics, not necessarily working with the same number of co-workers, but living in a city with twice the size have 4.6 percent higher earnings. The 1.3 percentage points decrease in the

cross-sectional comparison of earnings may be due to both the fact that by comparing workers with similar number of co-workers, we may be comparing more similar workers in terms of unobserved characteristics, and that, even for a particular worker, the earnings premium of moving to a larger city may be in part due to an increase in the number co-workers.

Including worker fixed effects leads us to conclude that a worker moving to a city with twice the size but staying with the same number of co-workers should expect a 1.4 percent increase in earnings. In comparison, a worker moving to a city with twice the size and not necessarily staying with the same number of co-workers should expect a short-term 2.3 percent increase in earnings. The 0.9 percentage points decrease suggests that almost 39.1 percent of a worker's expected increase in earnings is related to an increase in the number of co-workers.

Second, we investigate the change in the co-workers premium as a result of including city fixed effects. Column 1 of 4.1 shows that workers with similar characteristics and living the same city but with twice as many co-workers have 4.4 percent higher earnings. In comparison, workers with twice as many co-workers but not necessarily working in the same city have 4.9 percent higher earnings (Column 2 of 3.2). The fact that by comparing workers with different number of co-workers, we may be comparing workers in different cities, can only account for 11 percent of the earnings difference.

Finally, we control for unobserved characteristics by including worker fixed effects in Column 3 of Table 4.1. A worker moving to an employer with twice as many co-workers but staying in the same city, should expect 2.7 percent higher earnings, the same earnings increase as a worker moving to an employer with twice as many co-workers but not necessarily staying in the same city. Therefore, the co-workers premium cannot be explained by workers that increase their number of co-workers by simultaneously moving to a larger city.

4.2 Short-Term and Medium-Term Effects

Until now, we have focused on the average effect of increasing either city size or the number of co-workers, 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) found 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 effect in the medium-term 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 study dynamic effects, we follow the two-step procedure used by De la Roca and Puga (2017). In a first step, we regress earnings (or co-workers) on city fixed effects and

the number of years of experience working in each of the cities. Let's assume that wages for individual i, at time t are given by:

$$ln\left(w_{it}\right) = \alpha_{c(i,t)} + \sum_{j=1}^{C} \delta_{jc(i,t)} e_{ijt} + \mu_i + x_{it}^{'}\beta + \epsilon_{it}, \tag{4.1}$$

where $c\left(i,t\right)$ is the city where individual i lives at time t, $\alpha_{c(i,t)}$ is a city fixed effect, e_{ijt} is the number of years individual i worked in city j up to time t, 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 wage.

The short-term city-size premium β^{st} is then given by the coefficient on log size from the following regression:

$$\alpha_c = \beta^{st} ln\left(city\, size_c\right) + u_c \tag{4.2}$$

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

$$\alpha_c + \delta_{cc} mean\, experience = \beta^{mt} ln\left(city\, size_c\right) + u_c \tag{4.3}$$

The results are shown in Table 4.2. The first three columns capture the medium-term city size co-worker premium. We find that a worker moving to a city with twice the size should expect a 29.4 percent increase in the number of co-workers at the time of the move and a 32.4 percent increase after 8.9 years, where 8.9 years is the average experience accumulated in the current city for our sample[5]. There is only a small difference in the short- and medium-term effects which suggests that the number of co-workers increases only slightly faster in larger cities. The next two columns look at the short- and medium-term city-size earnings premium with and without controlling for the number of co-workers.

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. A worker moving to a city with twice the size should expect a 2.6 percent short-term increase in earnings, as captured in Column 5. This increase includes the effect of the increase in the number of co-workers. However, if we control for the number of co-workers the move to a city with twice the size is only associated with a 1.8 percent increase in earnings, as shown in Column 8. Therefore, the increase in the number of co-workers can account for 30.8 percent of the short-term city-size earnings premium.

Next, we decompose the medium-term city-size earnings premium. A worker moving to a city

[5]De la Roca and Puga (2017) find a lower average experience of around seven years. This is because of they use a slightly earlier period covering from 2004 to 2009. We find that the average years of experience is increasing in the sample from 2006 to 2013, which explains why we compute a different number. The reason for the increase in experience accumulated in the current city throughout the sample could be due to the effects of the financial crisis on the composition of the labor force.

Table 4.2: Dynamic City Size Premium

	Ln Cowork.	City FE	Med-term	Ln Earn.	City FE	Med-term	Ln Earn.	City FE	Med-term
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Ln City Size		0.294	0.324		0.026	0.044		0.018	0.035
		(0.0436)***	(0.0506)***		(0.0050)***	(0.0100)***		(0.0048)***	(0.0093)***
Ln Co-work.							0.027		
							(0.0005)***		
City FE	Y			Y			Y		
Worker FE	Y			Y			Y		
Controls	Y			Y			Y		
City-specific experience	Y			Y			Y		
N	7,019,750	76	76	7,727,861	76	76	7,019,750	76	76
R^2	0.240	0.416	0.450	0.346	0.201	0.358	0.371	0.126	0.296

** p<0.1; ** p<0.05, ***p<0.01*

Note: This table reports the result of regressing log establishment workers on city fixed effects and a series of controls, and then regressing the city fixed effects 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. Controls include some education, occupation category, and type of contract. Clustering is implemented at the person level. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.

with twice the size should expect a 2.6 percent short-term increase in earnings and a 4.4 percent increase after 8.9 years, as captured by Columns 5 and 6 respectively. Thus, the dynamic benefit of moving to a large city is 1.8 percentage points in the medium-term[6]. In Columns 8 and 9, we show that a worker moving to a city with twice the size and maintaining the same number of co-workers should expect a short-term 1.8 percent increase in earnings and a 3.5 percent increase after 8.9 years. Therefore, once we control for the number of co-workers, the dynamic benefits are 1.7 percentage points. This is just 0.1 percentage points lower than without controlling for the number of co-workers. This leads us to conclude that only 5.0 percent of the dynamic gains of large cities can be accounted for through the effect of large-city experience on the number of co-workers.

Notice that experience accumulated in larger cities may be positively correlated with experience accumulated in larger establishments. However, due to data limitations we do not observe the number of co-workers throughout a worker's labor history and thus are not able to separate the effect of large-city experience from the effect of large-establishment experience. Here, we are merely isolating the effect of large-city experience through an increase in the number of co-workers and find that this channel is not very important in explaining the dynamic benefits of large cities. This is consistent with the finding that the number of co-workers is increasing

[6] These columns replicate the results in Table 2 of De la Roca and Puga (2017). They find very close results (a short-term 2.2 percent and a 5.1 percent after 7.7 years). The difference is likely due to the fact that we use a different time period. While they use data for the years 2004 to 2009 we use 2006 to 2013.

only slightly faster in larger cities. Finally, we find that the co-worker earnings premium remains unchanged even controlling for city-specific experience, so that a worker that experiences a doubling in the number of co-workers without moving cities or changing city-specific experience should expect a short-term 2.7 percent increase in earnings.

5 Conclusion

This paper employs rich 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 more co-workers is associated with higher earnings. We find that around 30.8 percent of the short-term and 5.0 percent of the medium-term city-size earnings premium can be attributed to the climbing of the establishment-size ladder. Moreover, we find that doubling the number of co-workers and doubling the size of the city are associated with similar increases in earnings of 2.7 and 2.6 percent respectively. 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, which 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 Appendix

In this appendix, we explore the robustness of our main results. In the first section of the appendix we present some additional evidence on the correlation between establishment size, and city size as well as establishment size and city earnings. In the second section, we replicate the main results on the city-size earnings premium for establishment size dummies and firm size dummies.

A.1 Data Description

In this section, we present some summary statistics on the main variables, both of interest, and the ones used as controls for workers characteristics.

Table A.1: Summary Statistics

Variable	Units	Mean	Std. Dev.	Min	Max
Daily earnings	Euros	72.51	90.45	0.00	37,042.03
Number of co-workers	Persons	575.34	1,859.05	0.00	22,077
Age	Years	34.39	7.07	17.08	47.92
Less than high school education	Dummy	0.50	0.460.50	0.00	1.00
High school education	Dummy	0.31	0.46	0.00	1.00
University and above education	Dummy	0.19	0.39	0.00	1.00
Days worked in a month	Days	29.86	3.30	1.00	31.00
Tenure	Years	4.74	4.97	0.00	32.59
Experience	Years	11.23	6.48	0.00	36.59
Experience in 1st and 2nd largest cities	Years	4.39	6.45	0.00	31.43
Experience in 3rd, 4th, and 5th largest cities	Years	1.03	3.42	0.00	31.27
Experience outside the 5 largest cities	Years	4.29	6.07	0.00	33.45
Experience in the current city	Years	9.94	6.36	0.00	33.42
Fixed Contract	Dummy	0.28	0.45	0.00	1.00
Part-time Contract	Dummy	0.09	0.28	0.00	1.00
Very-high-skilled occupation	Dummy	0.08	0.27	0.00	1.00
High-skilled occupation	Dummy	0.12	0.32	0.00	1.00
Middle-skilled occupation	Dummy	0.23	0.42	0.00	1.00
Low-skilled occupation	Dummy	0.46	0.50	0.00	1.00
Very-low-skilled occupation	Dummy	0.11	0.31	0.00	1.00

A.2 Firm and Establishment Co-workers

This section explores whether establishment size or firm size seems more relevant both in terms of its correlation with city size and in terms of predicting wages. To examine this we first regress the log of establishment size for a worker i on city fixed effects γ_c and the log of firm size.

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

Table A.2: City Size Elasticity of Establishment and Firm Sizes

	Log Estab. Workers	City FE	Log Firm Workers	City FE
	(1)	(2)	(3)	(4)
Log Size		0.110**		-0.050
Time and Sector FE	Y		Y	
Log Firm Workers	0.671***		-	
Log Estab.Workers	-		1.151***	
N	7,019,750	76	7,052,593	76
R^2	0.836	0.085	0.8312	0.0098

** p<0.1; ** p<0.05, ***p<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.

We then regress the city fixed effects on log city size

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

We interpret θ as the elasticity of establishment size with respect to city size, controlling for firm size. Column 2 of table A.2 presents the estimated elasticity of establishment size with respect to city size, controlling for firm size, as well as the coefficient, β, on log firm size. Given firm size, workers in a city twice as large work for establishments with 11% more co-workers. Column 4 reports the estimated elasticity of firm size with respect to city size, controlling for establishment size. Given an establishment size, there is no further correlation between city size and firm size. Therefore, we will explore the effect of establishment size, although we will allow for firm size to vary together with establishment size so that when we talk about the effect of changing establishment size, this will include the corresponding change in firm size.

A.3 Establishment Size, City Size and Earnings

In this section, we present three additional robustness exercises on establishment sizes, city sizes and wages. Table **??** presents the correlation between establishment sizes and cit size selecting only movers. First looking at all periods, then only at the period before workers move and last at the period after they move. We find little evidence of movers looking different than the general population. Interestingly, the correlation of establishment size and city size is slightly smaller the period right after moving. This is in line with our finding that living in a large city may also have a dynamic effect through a faster growing establishment size relative to living in a small city.

Table A.3: Establishment and Firm Sizes Earnings Premium

Log Earnings	(1)	(2)	(3)
Log Establishment Workers	0.055***	0.021***	0.022***
Log Firm Workers	0.022***	0.026***	0.004***
Worker FE	N	N	Y
Controls	N	Y	Y
Observations	7,019,750	7,019,750	7,019,750
R^2	0.111	0.504	0.063

** p<0.1; ** p<0.05, ***p<0.001*

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.

Next, we look at the correlation between earnings and establishment sizes controlling for firm sizes and present the results in Table A.3. Both firms and establishment sizes are positively correlated with earnings. However, once we include both controls and worker fixed effects the effect of establishment size is about five times larger than firm size, suggesting that although both naturally move together, the establishment size is better predictor of earnings.

Finally, in Table A.4, we expand our industry by industry analysis of the elasticity of establishment sizes with respect to city size by including a worker fixed effect and a medium term effect that captures the medium run effect on establishment size of living in a larger city. Including worker fixed effects doesn't change the picture dramatically although it makes some of the elasticities not statistically different from zero and flips the sign for real estate.

A.4 City-Size Earnings Premium andCo-worker Size

In this section, we include some robustness checks for the main results. In Table A.5, we replicate the main results including dummies for firm sizes instead of log number of workers in an establishment. The decrease in the city size premium is somewhat smaller than with log establishment workers. However, we find it interesting that even this very coarse measure of firm size able to capture the sorting of individuals on unobservable characteristics since after controlling for firm size dummies including worker fixed effects does not affect the coefficient on city size. Table A.6 includes experience accumulated by firm size categories. Including this experience measure has a very small effect on the estimated coefficients.

Furthermore, in Table A.7 we repeat the exercise controlling only for dummies for establishment size instead of firm size. The coefficients are almost unchanged from including firm size dummies. Similarly, in TableA.8 we include both establishment size dummies and establishment size specific experience. The medium term effect decreases by 3 percentage points from 39 per-

Table A.4: City Size Elasticity of Establishment Size by Industry

Log Establishment workers	No Worker FE	Worker FE	Medium Term
Manufacturing	0.357***	0.155	0.214
Construction	0.268***	0.118*	0.193***
Retail and Wholesale	0.377***	0.294***	0.281***
Hotels	0.242***	0.352***	0.379***
Transportation	0.459***	-0.007	-0.013
Communication	0.846***	0.394***	0.388***
Finance	0.899***	0.540***	0.603***
Real Estate	0.336***	-0.475***	-0.435***
Rental Services	0.265***	0.806***	0.816***
Computer	0.622***	0.762***	0.771***
Research	0.722***	0.544***	0.598***
Professional Services	0.623***	0.565***	0.557***
Entertainment	0.250***	0.252**	0.240**
Personal Services	0.222*	-0.322	-0.306

** p<0.1; ** p<0.05, ***p<0.001*

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 industry by industry. 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. Medium-term is the estimated effect of living in the city for 8.9 years. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.3.

Table A.5: City-Size Earnings Premium with Firm Size Dummies

	Log earn.	City FE	Log earn.	City FE	Log earn.	City FE	Medium-term
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log city size		0.036***		0.022***		0.021***	0.039***
City FE	Y		Y		Y		
Controls	Y		Y		Y		
Worker FE	N		N		Y		
City Experience	N		Y		Y		
Firm Experience	N		N		N		
Large Firm	0.217***		0.215***		0.101***		
Medium Firm	0.111***		0.111***		0.051***		
N	7,727,861	76	7,727,861	76	7,727,861	76	76
R^2	0.515	0.175	0.518	0.078	0.060	0.159	0.32

** p<0.1; ** p<0.05, ***p<0.001*

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. Medium-term is the estimated effect of living in the city for 8.9 years. A small firm is a firm with fewer than 20 employees, a medium firm is a firm that has between 20 and 100 employees and a large firm is a firm with more than 100 employees Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.

Table A.6: City-Size Earnings Premium with Firm Size Specific Experience

	Log earn.	City FE	Log earn.	City FE	Log earn.	City FE	Medium-term
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log city size		0.035***		0.023***		0.022***	0.037***
City FE	Y		Y		Y		
Controls	Y		Y		Y		
Worker FE	N		N		Y		
City Experience	N		Y		Y		
Firm Experience	Y		Y		Y		
Large Firm	0.163***		0.167***		0.099***		
Medium Firm	0.082***		0.085**		0.048***		
N	7,727,861	76	7,727,861	76	7,727,861	76	76
R^2	0.517	0.169	0.520	0.085	0.061	0.162	0.31

** p<0.1; ** p<0.05, ***p<0.001*

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. Medium-term is the estimated effect of living in the city for 8.9 years. A small firm is a firm with fewer than 20 employees, a medium firm is a firm that has between 20 and 100 employees and a large firm is a firm with more than 100 employees Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.

cent higher earnings associated with living in a city with twice the size for 8.9 years to 36 percent higher earnings while it was 37 percent for firm size dummies.

Next, we investigate within industry differences in the city-size earnings gap and in the effect of controlling for establishment size. The results are summarized in Table A.9. Since we do not observe so many workers moving across cities, further reducing the observations to a particular industry reduces the statistical power greatly. Interestingly, there are two sectors that have a negative sign once we control for worker fixed effects. One of them is real estate, which was the one that also had a negative elasticity of establishment size with respect to city size, and the other is research and development. However, for both of these industries, the effect is not significant without worker fixed effects. It is possible that these are industries where movers are not representative of the population as a whole or where workers move in response to particularly good offers.

Finally, we look a little deeper into moves across cities an how they relate to moves across firm sizes. Table A.10 include the percentage of movers who move either from a small to a large city or from a large to a small city, that move across three firm size categories. In Table A.11 the percentages from moving from a small to a large city are compared to what would be expected if the moves across firm size categories were random, given the differences in firm size distributions across city sizes. We find that relative to random moves workers tend to move within a firm size category. This may explain in part why the effect of including firm size category is not so large despite large firm size premium and large differences in the firm size composition.

Table A.7: City-Size Earnings Premium with Establishment Size Dummies

	Log earn.	City FE	Log earn.	City FE	Log earn.	City FE	Medium-term
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log city size		0.036***		0.023***		0.022***	0.039***
City FE	Y		Y		Y		
Controls	Y		Y		Y		
Worker FE	N		N		Y		
City Experience	N		Y		Y		
Estab. Experience	N		N		N		
Large Establishment	0.186***		0.185***		0.083***		
Medium Establishment	0.109***		0.109***		0.048***		
N	7,727,861	76	7,727,861	76	7,727,861	76	76
R^2	0.508	0.173	0.512	0.082	0.057	0.156	0.321

** p<0.1; ** p<0.05, ***p<0.001*

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. Medium-term is the estimated effect of living in the city for 8.9 years. 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.

Table A.8: City-Size Earnings Premium with Establishment Size Specific Experience

	Log earn.	City FE	Log earn.	City FE	Log earn.	City FE	Medium-term
	(1)	(2)	(3)	(4)	(5)	(6)	
Log city size		0.035***		0.024***		0.022***	0.036***
City FE	Y		Y		Y		
Controls	Y		Y		Y		
Worker FE	N		N		Y		
City Experience	N		Y		Y		
Establishment Experience	Y		Y		Y		
Large Establishment	0.135***		0.11***		0.081***		
Medium Establishment	0.080***		0.083**		0.045***		
N	7,727,861	76	7,727,861	76	7,727,861	76	76
R^2	0.510	0.167	0.513	0.089	0.058	0.156	0.300

** p<0.1; ** p<0.05, ***p<0.001*

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. Medium-term is the estimated effect of living in the city for 8.9 years. 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.

Table A.9: City-Size Earnings Premium by Industry

	No Establishment Size			Log Establishment Workers		
Log Earnings	No Worker FE	Worker FE	Medium Term	No Worker FE	Worker FE	Medium Term
Manufacturing	0.058***	0.044**	0.061***	0.038***	0.049	0.061**
Construction	0.047***	0.048***	0.058***	0.035***	0.048***	0.056***
Retail and Wholesale	0.036***	0.016	0.031**	0.025***	0.009	0.024*
Hotels	0.026**	0.030*	0.047***	0.010	0.019	0.035**
Transportation	0.086***	0.070***	0.014***	0.055***	0.076***	0.089***
Communication	-0.010	0.011	0.040	0.011	-0.020	0.007
Finance	0.082**	0.018	0.033*	0.044	0.0253	0.048**
Real Estate	0.027	-0.067***	-0.045*	0.013	-0.059***	-0.039**
Rental Services	0.081***	0.118***	0.158***	0.076***	-0.053	-0.004
Computer	0.063**	0.041	0.057*	0.044**	0.014	0.028
Research and Development	-0.030	-0.200***	-0.178***	0.053	-0.210***	-0.186***
Professional Services	0.025**	0.019*	0.043***	0.007	-0.009	0.014
Entertainment	0.068***	0.081	0.085*	0.055***	0.079	0.076
Personal Services	0.068***	-0.073	-0.075	0.034*	0.413	0.419

** p<0.1; ** p<0.05, ***p<0.001*

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 industry by industry. 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. Medium-term is the estimated effect of living in the city for 8.9 years. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.

Table A.10: Moves across Firm Size Categories

		Moving from Small to Large Cities			Moving from Large to Small Cities		
	Moving to:	Large Firm	Middle Firm	Small Firm	Large Firm	Middle Firm	Small Firm
Moving	Large Firm	35%	8%	**8%**	37%	8%	**10%**
from:	Middle Firm	7%	6%	4%	8%	6%	6%
	Small Firm	**14%**	7%	11%	**9%**	5%	11%

Note: this table reports the percentage of people who move across city sizes that also move across firm sizes. A large city is defined as one of the three largegest 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 firm is a firm with fewer than 20 employees, a medium firm is a firm that has between 20 and 100 employees and a large firm is a firm with more than 100 employees. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.

Table A.11: Non-random Moves across Firm Size Categories

		Moving from a Small City to a Large City					
		Random			Data		
	Moving to:	Large Firm	Middle Firm	Small Firm	Large Firm	Middle Firm	Small Firm
Moving	Large Firm	23%	9%	11%	35%	8%	8%
from:	Middle Firm	12%	4%	6%	7%	6%	4%
	Small Firm	19%	7%	9%	14%	7%	11%

Note: this table reports the percentage of people who move across city sizes that also move across firm 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 largegest 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 firm is a firm with fewer than 20 employees, a medium firm is a firm that has between 20 and 100 employees and a large firm is a firm with more than 100 employees. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.