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JUE Insight: 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 premia 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 premia are closely related. We document that when workers move to larger cities, they also move to larger establishments. Hence, part of the benefit of 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 power, 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 (Henderson, 2003; Duranton and Puga, 2004; Rosenthal and Strange, 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 workers in cities twice as large earn, on average, 5.12 percent more, 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 worker at an establishment with twice as many co-workers,

[1] See Glaeser (1999); Glaeser and Maré (2001); Duranton and Puga (2004); Mion and Naticchioni (2009); 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. (2018); 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 with 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

earns 4.85 percent more on average.[5] Third, we document the *city-size co-worker premium*—the fact that workers in large cities work at larger establishments. The city-size co-worker premium is large; a worker in a city twice as large can expect 26.4 percent more co-workers.

We combine these facts to decompose the average city-size earnings premium into the contribution from increasing the number of co-workers 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 after controlling for observable and unobservable characteristics of the worker, 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.[6] 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.

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 as large, 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.[7]

There is substantial heterogeneity in the co-worker earnings premium across cities. 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.[8] This novel fact dampens the role of establishment size in contributing to the medium-term city-size earnings premium. While workers in large cities move to large establishments slightly faster, they receive a smaller earnings premium as they move up the establishment-size distribution. As a result, only 4.88 percent of the medium-term earnings gains in larger cities can be

the relationship between average pay per employee and firm size using firm or establishment-level data as is 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] 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) who estimates the co-worker earnings premium when a worker first enters the labor market using the same data.

[6] Note that the short-term city-size earnings premium is larger than the average. This is due to a composition effect of experience in large cities, as we discuss in Section 3.3.

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

[8] 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 to large cities where they will face a more elastic labor supply (Manning, 2010).

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. Finally, we also explore heterogeneity in the city-size co-worker premium across sectors. One might expect that establishments are larger in large cities simply due to market size effects. However, we find that the city-size co-worker premium is remarkably constant across tradable and non-tradable sectors suggesting that market size is unlikely to be the driver.

Our analysis allows us to gauge the importance of establishment size in the city-size earnings premium. However, we do not interpret our exercise as providing causal estimates of the role of establishment size on earnings across cities. In each of the relationships we examine, reverse causality and omitted variables are potential sources of bias to a causal estimate. For example, when studying the role of city size on the number of co-workers, unobserved local productivity effects could simultaneously lead firms and cities to be larger (Manning, 2010). In addition, there may be firm-level productivity effects, with more productive firms being both larger and offering higher wages. In the absence of a precise measure of productivity in our dataset, we follow much of the literature and consider an establishment's number of co-workers as a key characteristic that is easily observable, tightly linked to unobserved productivity (Combes et al., 2012; Mion and Naticchioni, 2009), and directly relevant for several important theories of firm wage setting, such as monopsonistic labor markets (Manning, 2010) and efficiency wages (Brown and Medoff, 1989).

This paper primarily contributes to the literature on the city-size and establishment-size earnings premia. Although the two premia 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 premia 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 large 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 large city. Taken together, these three facts may be satisfied by a model in which firms sort to large 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 and presents the methodology we use for the main decomposition exercise. Section 3 starts by documenting three stylized facts on the co-worker earnings premium, the city-size earnings premium, and the city-size co-worker premium. Then it presents the main results decomposing the city-size earnings premium into

[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.

the city premium and the co-worker premium. In Section 4, we examine heterogeneity in the city-size co-worker premium across sectors and heterogeneity in the co-worker earnings premium across cities. In both cases, we discuss the implications of this heterogeneity for the main decomposition exercises.

2 Data and Methodology

2.1 Data

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.[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 only 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, and 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's relationship with the SSA since they first entered the labor force. This long-run dimension allows us to construct 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. However,

[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.

a drawback of the data is that, although we can observe the number of workers in an establishment, we do not observe information about the co-workers unless they happen to be randomly selected into the 4% sample. As such, we are not able to control for establishment-level fixed effects in our analysis. Furthermore, we can only observe the number of co-workers at an establishment starting in 2006, which means we cannot construct measures of a worker's experience in large and small establishments.[14]

2.2 Methodology

Previous work by De la Roca and Puga (2017) documented that experience accumulated in larger cities results in faster earnings growth, and that this accounts for a significant fraction of average city-size earnings premium. In this paper, we look at the effect of controlling for the number of co-workers on the estimation of the average city-size earnings premium, as well as on its decomposition into the short- and medium-term effects of moving to a larger city. 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, experience in cities of different sizes, and controls. Second, we regress the city fixed effects and the city fixed effects adjusted for experience 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.[15]

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:

$$\ln(w_{it}) = \alpha^a_{c(i,t)} + \delta_t + \mu_i + x'_{it}\psi + \epsilon_{it}, \tag{1}$$

where $c(i,t)$ is the city where individual i lives at time t, $\alpha^a_{c(i,t)}$ is the corresponding city fixed effect, where the superscript a indicates that we estimate the city effect as an average over the years spent by an individual in a given city, 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.[16] For reference, Section A.2 of the Appendix includes a table with the summary statistics for the regressors and variables of interest.

The city fixed effect $\alpha^a_{c(i,t)}$ gives the average earnings of an individual who moves to a larger city regardless of their accumulated experience in the city. To obtain the short- and medium- term effects of living in a large city, we further control for experience accumulated in cities of different sizes.

[14] See Section A.1 for more details.

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

[16] 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.

We run a regression of log earnings w_{it} for individual i, at time t:

$$\ln(w_{it}) = \alpha^s_{c(i,t)} + \sum_{g=1}^{G} \left(\phi_{gh(c(i,t))} e_{igt} + \gamma_{gh(c(i,t))} e^2_{igt}\right) + \delta_t + \mu_i + x'_{it}\psi + \epsilon_{it}, \tag{2}$$

where $\alpha^s_{c(i,t)}$ is the short-term 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 the city in which 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 subsets defined by size quantiles. 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 subsets defined by size quantiles and denote by $h(c(i,t))$ the subset to which worker i's current city $c(i,t)$ belongs. We allow the experience accumulated in each subset g to have a specific effect on earnings in each subset 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 ϕ_{gh} and γ_{gh} represent the effect of experience and experience squared, respectively, acquired in cities in subset g when the worker is currently in a city in subset h. The remaining terms include a month-year fixed effect, δ_t, an individual fixed effect μ_i, and observable characteristics of the worker x_{it}.

We define the average and the short-term city-size premium β^τ, $\tau \in \{a, s\}$, as the coefficient on log city size from the following regression:

$$\alpha^\tau_c = \beta^\tau \ln(\text{city size}_c) + u_c, \tag{3}$$

where α^τ_c is either the average or short-term city-size fixed effect of a given city c.[17] The medium-term city-size premium is defined as $\beta^m - \beta^s$, where β^m is the coefficient on log size from the following regression:

$$\alpha^s_c + \phi_{g(c)h(c)}\text{mean experience} + \gamma_{g(c)h(c)}\text{mean experience}^2 = \beta^m \ln(\text{city size}_c) + u_c, \tag{4}$$

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 the gains from earnings growth with experience associated to living in a city of a specific size, net of the short-term earnings gains.

The specifications of equation (1) with worker fixed effects and of equation (2) with an additional role for experience by city size allow us to account for the sorting of individuals across cities based on unobservable characteristics (Glaeser and Maré, 2001; Combes et al., 2008) and for the differential value

[17] As is common in the literature, we often discuss the expected change in earnings associated to doubling city size. To transform β into this number, consider a city c with population X and consider a counterfactual city c' identical in everything but with population $2X$. For these two cities, the predicted incomes are, respectively, $\ln \hat{w}_c = \hat{\alpha}_c + \hat{\beta} \ln(X)$ and $\ln \hat{w}_{c'} = \hat{\alpha}_{c'} + \hat{\beta} \ln(2X)$. Since the fixed effects are the same, taking the difference between the equations for the fitted value and exponentiating both sides gives $\frac{\hat{w}_{c'}}{\hat{w}_c} = \exp(\hat{\beta} * \ln(2))$.

of experience accumulated in larger cities (Glaeser, 1999; De la Roca and Puga, 2017). However, each of the stylized facts that we document present challenges for any causal interpretation.

First, if one were interested in studying the causal effect of city size on earnings, several sources of potential bias would have to be examined in the second-stage estimation of equations (3) and (4). The city fixed effects α_c estimated in equation (2) capture the unobserved drivers of individual earnings that are common within a city. If these unobserved drivers are distinct from city size, then they will be part of the error term u_c in equation (3). If they are correlated with city size, they would lead to a bias in the causal estimates of city size on earnings and establishment size. For example, being on the seaside, which is enjoyed by workers and benefits firms through access to ports, might increase earnings while simultaneously increasing city size—leading, in this case, to an upward bias in β^{τ}. Reverse causality could also drive this relationship if higher earnings leads to in-migration, increasing city size. This would also cause an upward bias of the causal effect of city size on earnings. These concerns have been examined by an extensive literature (Ciccone and Hall, 1996; Greenstone et al., 2010; Combes et al., 2010; De la Roca and Puga, 2017), and have been found to be of minor consequence.[18] Nevertheless, we abstain from drawing any causal interpretation from our analysis of the role of city size on earnings.

Second, omitted variable bias would also be a concern if one wanted to estimate the causal effect of city size on establishment size. For example, unobserved local productivity effects are likely to simultaneously lead establishments and cities to be larger (Manning, 2010)—leading to an upward bias of the causal effect of city size on establishment size. Moreover, the presence of a particularly productive establishment might cause the city to grow, leading to reverse causality (Greenstone et al., 2010). Instead, our analysis focuses on uncovering the part of the variation of earnings across cities that can be accounted for by variation in the number of co-workers, while remaining agnostic on causal links between city size and the number of co-workers.

Third, there may be omitted variable bias if one wanted to study the causal effect of the number of co-workers on earnings. On the one hand, there may be establishment-level productivity effects, with more productive establishments being both larger and offering higher wages. This would be the case if more productive establishments pass some of their profits to their workers, causing an upward bias in the causal effect of establishment size on earnings. On the other hand, some establishments might offer amenities that allow them to grow large while paying relatively less, causing a downward bias. In the absence of a measure of establishment productivity, we follow much of the literature in considering an establishment's size as a key characteristic, that is easily observable, tightly linked to unobserved productivity (Combes et al., 2012), and directly relevant for several important theories of firm wage setting, such as monopsonistic labor markets (Manning, 2010) and efficiency wages (Brown and Medoff, 1989). If we were trying to measure the causal effect of establishment productivity on earnings, then using establishment size as a proxy could also cause bias as size is also correlated with many other

[18] De la Roca and Puga (2017) instrument city size with several persistent geographic determinants of city size and find that the elasticity of earnings premium with respect to city size is very similar to the one obtained by ordinary least squares. Relative city sizes are remarkably stable over time (Eaton and Eckstein, 1997; Black and Henderson, 2003), and contemporaneous earnings differentials typically explain a small part of cities' different sizes.

characteristics of the establishment.[19] For these reasons, we do not assign any causal interpretation to our analysis of the number of co-workers on earnings.

Finally, the correlations we document could be driven by the interaction of several of these unobserved place and establishment fundamentals. For example, if more productive establishments benefit more from agglomeration economies (Gaubert, 2018; Baum-Snow et al., 2021), this would lead to assortative matching of larger and more productive establishments to larger cities. In this case, the fact that the city-size earnings premium is partly explained by establishment size would be driven by this sorting. As we show in the next section, there remains a significant role for city size in explaining earnings after we control for establishment size. This implies that larger cities also offer high earnings through other channels than simply attracting larger establishments.

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

In this section, we present our main exercise evaluating the importance of the co-worker earnings premium in accounting for the city-size earnings premium. We start by presenting the three stylized facts which motivate this exercise: (1) the city-size earnings premium, (2) the co-worker earnings premium, and (3) the city-size co-worker premium. Next, we evaluate how much of the average city-size earnings premium can be explained by differences across cities in establishment size, not accounting for how the earnings premium changes as workers accumulate experience in large cities. Finally, we decompose the short-term and medium-term gains of living in a large city into a portion that can be accounted for by differences in establishment size.

3.1 Three Stylized Facts

Figure 1 presents scatter plots showing 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 0.072, meaning that workers in cities with twice the population have on average 5.12 percent higher earnings.[20] In Appendix B.1, we show that a significant part of this difference can be accounted for by systematic differences across cities between workers' observable characteristics such as sector, occupation, education, experience, tenure, and whether the contract is part-time. We further control for unobserved worker characteristics by adding worker fixed effects and find that the city-size earnings premium decreases but remains significantly positive.

Next, Panel B of Figure 1 documents the co-worker earnings premium, or the correlation between the number of co-workers and earnings in the data. The elasticity between earnings and the number of co-workers is 0.068, implying that workers with twice as many co-workers have, on average, 4.85 percent higher earnings. In Appendix B.1, we again show that controlling for a broad set of observable worker

[19] For example, there is evidence in support of establishment size capturing how much production is standardized vs. customized (Holmes and Stevens, 2014) or the level of transport-intensive activities (Lafourcade and Mion, 2007)

[20] This result applies the formula from footnote 17. Given an estimated elasticity of $\hat{\beta} = 0.072$, the percent increase in earnings associated with a doubling in city size, $x'/x = 2$, is equal to $(y' - y)/y \cdot 100 = (\exp(0.072 * \ln(2)) - 1) \cdot 100 = 5.12$.

characteristics and worker fixed effects reduces the elasticity. Moving to an establishment with more co-workers is associated with large earnings gains. As we discussed in the introduction, the co-worker earnings premium could be driven by the fact that larger establishments have to offer higher wages to grow and maintain their size in monopsonistic labor markets. It could also be that larger establishments are more productive, and are able to offer higher wages (either through profit sharing or efficiency wages). Under this second interpretation, establishment size would be a proxy for establishment productivity. In Section 4, we find some support for the first interpretation. We show that the co-worker earnings premium is decreasing with city size, and argue that this is consistent with theories in which firms have less monopsony power in big cities (Manning, 2010).

Finally, Panel C of Figure 1 documents the positive correlation between the number of co-workers and city size, which we refer to as the city-size co-worker premium. The elasticity of the number of co-workers with respect to city size is 0.338, meaning that workers in cities twice as large have on average 26.40 percent more co-workers. This correlation could be driven by the fact that workers in larger cities may have characteristics that make them more likely to work in larger establishments. That is, these workers would work in large establishments even if they were located in smaller cities. To address this possibility, in Appendix B.1 we control for observable and unobservable characteristics and find that the city-size co-worker premium is unchanged. This suggests that the city-size co-worker premium is not driven by systematic differences across cities in individual characteristics. In contrast, we do find that the systematic differences between workers across cities explain part of the city-size earnings premium.

3.2 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 worker 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 with a transition to a larger city while leaving the number of co-workers unchanged. The results of this exercise are included in Table 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 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 twice as large have 3.32 percent higher earnings. In column 2 of Table 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. It is important to keep in mind that when we control for the number of co-workers, we also capture the effect of unobserved establishment characteristics correlated with the number of co-workers that are not included in the controls, such as productivity. Thus, it is the change in the number of co-workers, and

potentially other correlated characteristics, that 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 twice as large and not necessarily holding the same number of co-workers fixed should expect a 1.63 percent increase in earnings on average. In comparison, when controlling for the 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 twice as large can be accounted for by the increase in the number of co-workers.

There are two differences between the regressions with and without worker fixed effects that could drive this decrease in the city-size earnings premium. First, as intended, the decrease could be due to controlling for the sorting of workers across city sizes 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. In the specification with worker fixed effects, the city-size earnings premium is identified from a selected sample—the sub-sample of workers who move across cities at least once—rather than the full sample of all workers. Subsection B.3 of Appendix B explores which of these two differences is more important. We find that the city-size earnings premium estimated without individual fixed effects is not significantly different for the sub-sample of workers who move compared to the full sample of workers. This suggests that identifying the city-size earnings premium from the sub-sample of movers is not the reason we find a lower city-size earnings premium when adding worker fixed effects.

Next, we investigate the change in the co-worker earnings premium as a result of including city fixed effects. In the first step, reported in column 2 of Table 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 B.1, the elasticity was 0.0492. Hence, the fact that by comparing workers with a 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 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 B.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. This does not mean that the co-worker earnings premium does not vary across cities. In fact, we find that it is declining in city size, which we discuss in Section 4.2. Instead, this means that the average co-worker earnings premium after removing city effects is similar to the national co-worker earnings premium.

Instead of directly controlling for the number of co-workers in the regression as in Table 1, an alternative way to evaluate the importance of the number of co-workers in the city-size earnings premium is to focus on sub-samples of workers who transition between establishments, but still maintain a similar number of co-workers. In Appendix B.4, we estimate the city-size earnings premium for three sub-samples of workers: those who move from large establishments to large establishments, from medium

to medium establishments, and small to small establishments.[21] We find that the city-size earnings premium is similar across all three sub-samples and similar to our estimates with the full sample (column 4, Table 1) in which we directly controlled for the number of co-workers. Particularly, the city-size earnings premium is not larger for workers who transition from large to large establishments. This suggests that our findings are not driven by unobserved city advantages that would disproportionately benefit larger establishments.

3.3 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 worker's 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 the 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.

The results are shown in Table 2. For the reasons discussed in Section 3.2, 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 twice as large 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 twice as large. Therefore, the increase in the number of co-workers can account for 29.4 percent of the short-term city-size earnings premium. As discussed in Section 3.2, the increase in the number of co-workers may be associated with changes in other unobserved establishment characteristics correlated with establishment size. It is the combination of these characteristics that accounts for 29.4 percent of the city-size earnings premium.

We note 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

[21] For this analysis, we classify establishments into large if they have more than 100 workers, medium if they have between 20 and 100 workers, and small if they have fewer than 20 workers.

of earnings with city size when we do not control for experience in large cities. This also helps us understand why the share of the short-term city-size earnings premium that can be accounted for by establishment size (29.4 percent) is smaller than for the average city-size earnings premium (38.2 percent). While the short-term city-size earnings premium is larger than the average, workers with no experience in large cities who move to large cities tend to experience a smaller increase in their number of co-workers (29.3 percent more co-workers, according to Table B.8) than other movers (33.2 more co-workers on average, according to Table B.1). Thus, establishment size accounts for a smaller share of the short-term city-size earnings premium.

Next, we decompose the medium-term city-size earnings premium. In column 3, the total city-size earnings premium is 0.0441. Hence, a worker moving to a city twice as large 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 gain of 3.10). In Column 4, the total city-size earnings premium, controlling for the number of co-workers, is 0.0355. This implies that a worker moving to a city twice as large 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 and on unobserved characteristics that are correlated with establishment size. We test whether this 4.88 percent is statistically different from zero by bootstrapping the standard errors of these estimates. We find that we can not reject that there is no effect of the number of co-workers on the medium-term gains of living in a large city at the 10 percent level.

The small contribution of establishment size to the medium-term gains can be explained by two facts. First, as we will discuss in Section 4.2, 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.6.1 of the Appendix, we find that the short- and medium-term city-size co-worker premia 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.6.2 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.

4 Heterogeneity

4.1 Heterogeneity in the city-size co-worker premium by sector

In this section, we explore the heterogeneity of the city-size co-worker premium across industries. It may not come as a surprise that local employment is larger in large cities if establishment size is driven by local 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 most models of firm dynamics, productivity and firm size are tightly linked. If instead the city-size co-worker premium were all driven by market access, we might not expect it to be correlated with the productivity of the firm.

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. 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 city-size co-worker premium is not solely driven by local market size. Instead, it is likely driven by differences in establishment productivity or in the elasticity of labor supply faced by establishments in large cities. Although our data does not allow a further evaluation of the first channel, in the next section, we find evidence in support of the hypothesis that establishments in larger cities face a more elastic labor supply, allowing them to grow larger.

4.2 Heterogeneity in the co-worker earnings premium across cities

Finally, we examine the heterogeneity of the co-worker earnings premium across cities. Moving to an establishment with more co-workers is associated with large earnings gains. However, 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 remaining in the same city and we show that it is decreasing in city size. Figure 2 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, as well as excluding the largest 5 cities in Subsection B.5 of Appendix B.

The lower co-worker earnings premium in larger cities is consistent with the hypothesis that establishments in large cities have less monopsony power. For example, in Manning (2010), large establishments sort to large cities because they face a higher elasticity of labor supply in large cities, i.e. they have less monopsony power. This implies that in order to grow large, establishments do not need to raise wages as much in a large city relative to a small city, leading to a weaker relationship between establishment size and earnings in large cities. In this view, the higher labor supply elasticity in larger cities acts as a source of agglomeration for establishments. Understanding what gives rise to these larger labor supply elasticities in larger cities and the implications for the spatial distribution of economic activity are interesting avenues for future research.

5 Conclusion

This paper employs administrative data from Spain to document several stylized facts: the city-size earnings premium, the co-worker earnings premium, the city-size co-worker premium, and the relationship between the within-city co-worker earnings premium and city size. We ask how much of 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. Such theories could explain why a portion of the city-size earnings premium can be accounted for by differences in establishment-size composition across cities.

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Table 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
First step 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. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Table 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		Short + 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	7,308,794	7,308,794	7,308,794	7,308,794
First step R^2	0.389	0.425	0.389	0.425

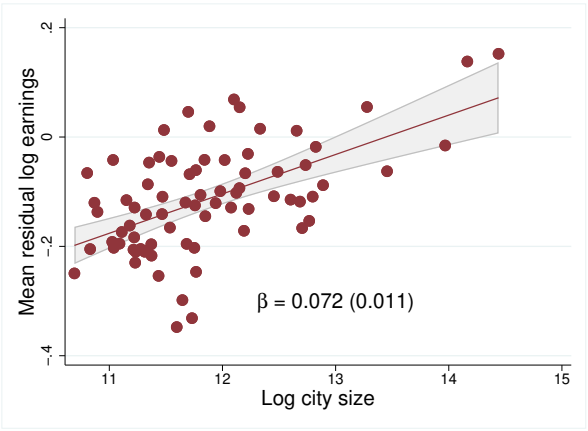
Note: The top part of the Table reports the results of the second step. Column 1 and 2 consist in regressing the city fixed effects on log city size. Columns 3 and 4 consist in regressing the city fixed effects, augmented by the effect of average experience in the city, on city size. In the first step, 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. The difference between the medium-term and short-term gains in the case where we control for the number of co-workers (columns (4) minus (2), giving an estimate of 0.0166) versus when we do not control for the number of co-workers (columns (3) minus (1), giving an estimate of 0.0174), is 0.0008. A test of significance of this difference with bootstrapped standard errors reveals that it is not significantly different from zero at the 10% level. 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. * $p<0.1$; ** $p<0.05$, *** $p<0.01$.

Table 3: City Size Co-worker Premium by Sector

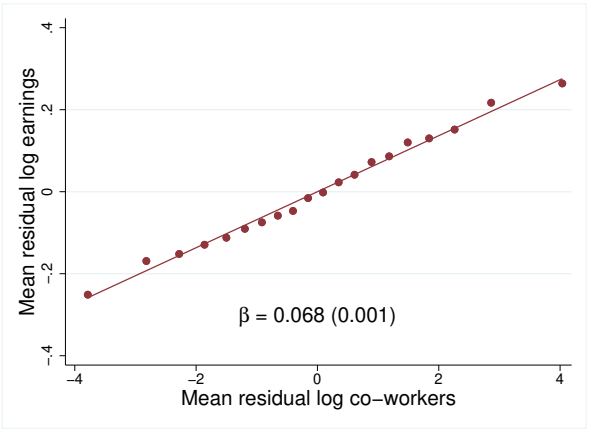
Tradables		Non-tradables	
Manufacturing	0.456	Real Estate	0.346
	(0.0327)***		(0.0320)***
Communication	0.445	Rental Services	0.374
	(0.0317)***		(0.0331)***
Professional Services	0.454	Construction	0.400
	(0.0321)***		(0.0322)***
Computer	0.402	Retail and Wholesale	0.418
	(0.0316)***		(0.0323)***
Research 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. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

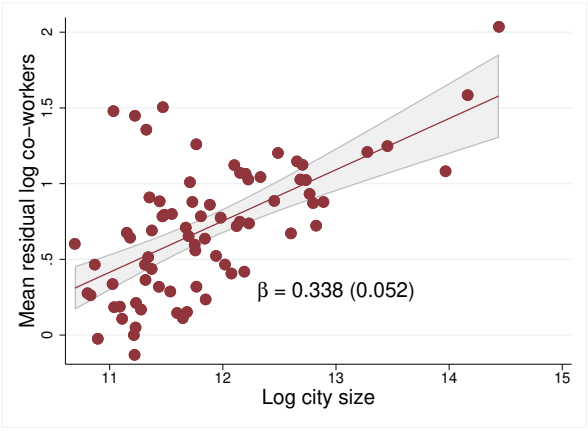
Figure 1: Three Stylized Facts



(a) City-size earnings premium



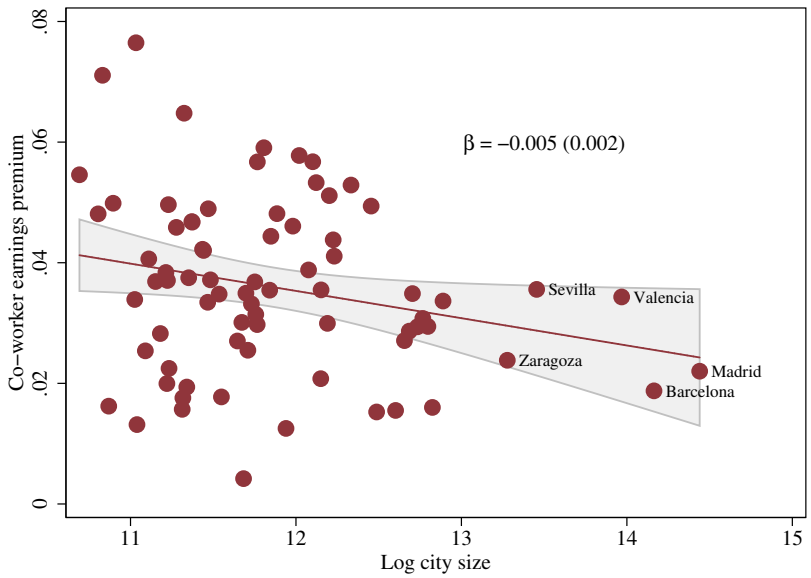
(b) Co-worker earnings premium



(c) City-size co-worker premium

Note: Panel (a) plots the city fixed effects of a regression of log earnings on city, sector, and month fixed effects. Panel (b) is a binned scatter plot of residual log earnings on residual log number of co-workers where the residuals are obtained by first regressing log earnings and the number of co-workers on sector and month-year fixed effects. Panel (c) plots city fixed effects of a regression of log number of co-workers on city, sector, and month-year fixed effects. The beta coefficients capture the slope of the linear fit, with the standard error in parentheses. 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 2: 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. The slope of the line is -0.005 with a standard error of 0.002, which is significantly different from zero at the 1% confidence level. The regression coefficient is very similar when dropping the four largest cities but the estimated coefficient is no longer significant at a 10% confidence level. The full regression table and the robustness to dropping the 5 largest cities can be found in Subsection B.5 of the Appendix. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.

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.

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 the overall population but also on how spatially concentrated the population is. As shown in De la Roca and Puga (2017), the measures of density are very highly correlated with total population counts. 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 an 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.[22]

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 B.2 of the Appendix, we test which of the establishment's or the firm's number of co-workers seems more relevant for determining the co-worker earnings premium. We find that the number of 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 the firm's co-workers instead of the establishment co-workers in Section B.2 of the Appendix.

Experience. We are particularly interested in constructing variables capturing aspects of accumulated experience in an urban area. 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. 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 overtime hours and other in-kind payments. Second, the tax administration records include all monetary and in-kind labor earnings in a given year and are 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 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.[23] Table A.1 in-

[22] 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.

[23] 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 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.

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.

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				

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 to ours as possible, given the available characteristics. We keep only males, from 15 to 54, born in Spain, 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 in three age categories: 15 to 24, 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. To compute the average age, we use the median age in each category. 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 more common than in the EU-LFS.

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				

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.

B Additional Results

B.1 Three Stylized Facts: Details

In Figure 1 we show three stylized facts: the city-size earnings premium, the co-worker earnings premium, and the city-size co-worker premium. In this section, we present regression results for the same stylized facts showing that they are robust to controlling for observable characteristics of the workers such as age, occupation, education, and unobservable characteristics (in the form of worker fixed effects).

Table B.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
First step R^2 Panel A	0.202	0.491	0.426
First step 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 always control 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. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Panel A of Table B.1 shows the city-size earnings premium, that is, 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. 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.

Next, Panel B of Table B.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.

Finally, Panel C of Table B.1 documents the positive correlation between the 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 twice as large 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-worker premium. That is, workers who select into larger cities tend to have characteristics that make them higher earners, as shown in Table B.1, but these characteristics do not make them significantly more likely to work with 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.

B.2 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

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

We interpret θ as the city-size co-worker premium, controlling for firm size. Column 2 of Table B.2 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 0.117, implying that given firm co-workers, workers in a city twice as large have on average 8.11 percent more co-workers in their establishment. Column 4 of table B.2 reports the city-size co-worker premium at the firm, controlling for establishment co-workers. Given the 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. 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. 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 incorporates the change in co-workers at the firm level.

Table B.2: City Size Co-worker Premium: Establishments vs Firms

	(1)	(2)	(3)	(4)
	Ln Estab. Co-Workers	City FE	Ln Firm Co-Workers	City FE
Ln City Size		0.117		-0.046
		(0.069)*		(0.085)
Ln Estab. Co-Workers			1.065	
			(0.002)***	
Ln Firm Co-Workers	0.700			
	(0.002)***			
Time and Sector FE	Y		Y	
Observations	7,308,794	76	7,308,794	76
R^2	0.771	0.828	0.7743	0.005

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. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

B.3 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 the 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), such 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 Column 2 of Table B.3 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. This difference is not statistically different from zero. Therefore, it doesn't seem that workers who move at some point are much different than the general population.

Table B.3: 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
	(0.008)***	(0.008)***
Worker Fixed Effects	N	N
Controls	Y	Y
Observations	76	76
R^2	0.24	0.28

Note: 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. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Next, we look deeper into moves across cities and how they relate to moves across establishment sizes.

We documented that larger cities are host to larger establishments and that workers moving to larger cities tend to transition to larger establishments. We are interested here in whether these transitions to larger establishments can be fully accounted for by the differences in establishment size distributions across cities, or whether they partly reflect some selection of movers to larger establishments—this could happen if, say, workers were to move to larger cities conditional on receiving an offer from a large establishment. To investigate this question, in Table B.4, 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 sorting of workers to establishment sizes. Importantly, we do not find evidence of selection of workers towards large establishments. On the contrary, workers moving to large cities are less likely to transition to a large establishment than if they were matched randomly to an establishment size category.

Table B.4: Transitions Across Establishment Size Categories for Individuals Moving from Small to Large Cities

	Moving to:	Large Estab.	Medium Estab.	Small Estab.	
		Random Matching Across Size Categories			
Moving from:	Large Estab.	14%	7%	8%	
	Medium Estab.	14%	7%	8%	
	Small Estab.	20%	10%	12%	
		Data			χ^2 Goodness of Fit Test (p-values)
Moving from:	Large Estab.	13%	7%	6%	0.00
	Medium Estab.	13%	10%	9%	0.00
	Small Estab.	16%	13%	13%	0.00

Note: This table reports, in the upper part, among the people who moved from small cities to large cities, what the shares of transitions between establishment size categories would have been if individuals had been matched to establishments randomly, i.e. with transition probabilities reflecting the number of jobs in each establishment size category in the origin and destination. In the lower part, the table reports the percentage of moves across establishment size categories in the data, among the people that moved from small to large cities. A large city is defined as one of the four largest cities, that is, Madrid, Barcelona, Valencia and Sevilla, and a small city refers to a city that is not in the top four largest cities. A small establishment is an establishment with fewer than 20 employees, a medium establishment has between 20 and 100 employees and a large establishment has more than 100 employees. The last column reports the results of a chi-square goodness-of-fit test, which tests the hypothesis that the distribution of transitions to destination establishment sizes in the data follows the conditional distribution of transitions from the random matching, for each establishment size category in the origin. The tests strongly reject random matching. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.

Table B.5: Wage Gains for Transitions Across Establishment Size Categories for Individuals Moving from Small to Large Cities

	Moving to:	Large Estab.	Medium Estab.	Small Estab.
		Random Matching Across Size Categories		
Moving from:	Large Estab.	26%	9%	-14%
	Medium Estab.	51%	30%	2%
	Small Estab.	82%	57%	23%
		Data		
Moving from:	Large Estab.	15%	13%	11%
	Medium Estab.	20%	17%	14%
	Small Estab.	33%	22%	19%

Note: This table reports, in the upper part, among the people who moved from small cities to large cities, what the shares of transitions between establishment size categories would have been if individuals had been matched to establishments randomly, i.e. with transition probabilities reflecting the number of jobs in each establishment size category in the origin and destination. In the lower part, the table reports the percentage of moves across establishment size categories in the data, among the people that moved from small to large cities. A large city is defined as one of the four largest cities, that is, Madrid, Barcelona, Valencia and Sevilla, and a small city refers to a city that is not in the top four largest cities. A small establishment is an establishment with fewer than 20 employees, a medium establishment has between 20 and 100 employees and a large establishment has more than 100 employees. The last column reports the results of a chi-square goodness-of-fit test, which tests the hypothesis that the distribution of transitions to destination establishment sizes in the data follows the conditional distribution of transitions from the random matching, for each establishment size category in the origin. The tests strongly reject random matching. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013.

Complementing the exercise in Table B.4, Table B.5 shows the average earnings gains from moving across establishment size categories for workers who move from a small to a large city. The first panel (labeled *Random Matching*) shows what these gains would be if workers received the average wage prevailing in each bin. The second panel (labeled *Data*) shows the actual wage gains these workers receive when moving.

The earnings gains reported in the *Random Matching* panel feature a larger variation than in the *Data* panel. This is expected since these first gains are computed by comparing the earnings of different workers and conflating the city- and establishment-size effects with the effect of sorting of individuals on observable and unobservable characteristics. In contrast, the *Data* panel compares the earnings of the same individuals as they transition across city size and establishment size categories. Despite the difference in magnitude, the ordering of the gains is the same in both panels: the smaller the establishment in the origin and the larger the establishment in the destination, the higher the wage gain.

Looking along the diagonal of each matrix, we can see that moving to a large city while remaining in the same establishment size bin, confers upon the worker a similar earnings premium (15, 17, and 19 percent in the data, respectively). This is consistent with the existence of a city-size earnings premium

that accrues to all workers, regardless of their establishment size categories.

However, when workers move across establishment size categories, the earnings premium is different, with larger gains seen for workers who move from small to large establishments (33 percent), and smaller gains for workers who move from large to small establishments (11 percent). This is consistent with establishment size having an important role in generating the overall city-size earnings premium.

B.4 Subsample analysis of the city-size earnings premium

In this section of the Appendix, we present the results from an alternative method to control for the number of co-workers. In the main analysis, we show that a significant part of the city-size earnings premium can be attributed to an increase in the number of co-workers. To show this, we estimate the city-size earnings premium with and without including the log number of co-workers as a control in regression 1. Here, we present the results of controlling for the number of co-workers in an alternative way.

We proceed in two steps. First, we classify all the establishments into three categories based on the number of co-workers. Establishments with more than 100 workers are classified as large, those between 20 and 100 as medium, and those with fewer than 20 workers as small. Second, we perform a sub-sample analysis in which we estimate the city-size earnings premium only for those workers that change their establishment but remain in the same size category. In other words, each sub-sample includes, for each worker, all the time periods before and after a move across establishments in the same size category. All of the regressions include controls for observable worker characteristics and worker fixed effects.

Table B.6: The Average City-Size Earnings Premium for a Subsample of Transitions Between Establishments

	(1)	(2)	(3)	(4)	(5)
	Ln Earnings City FE from Step 1				
Ln City Size	0.0233	0.0144	0.0135	0.0196	0.0167
	(0.0050)***	(0.0048)***	(0.0088)	(0.0108)*	(0.0084)**
Observations	76	76	76	76	76
R^2	0.169	0.081	0.051	0.0236	0.0422
	Step 1: Ln Earnings				
Ln Co-Workers		0.0269			
		(0.0005)***			
City FE	Y	Y	Y	Y	Y
Worker FE	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y
Transitions	All	All	Large to Large	Med. to Med	Small to Small
Observations	7,308,794	7,308,794	971,039	305,696	1,038,110
First step R^2	0.427	0.455	0.326	0.239	0.230

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. Column 2 performs the same analysis as in Column 1 but controlling for log number of co-workers. Column 3 selects only individuals that transition between establishments in the same size category. Large establishments have more than 100 workers, medium establishments, between 100 and 20 workers, and small establishments have fewer than 20 workers. Clustering is implemented at the person level. Data Source: Spain's Continuous Sample of Employment Histories 2006-2013. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Table B.6 presents the results from the sub-sample analysis. To ease comparison, in the first two columns we copied the results from columns (3) and (4) of Table 1, using the full sample. These columns present the estimates of the average city-size earnings premium with and without controlling for the number of co-workers. Columns (3) to (5) repeat the estimate in Column (1) for the sub-sample of workers moving across large, medium, and small establishments, respectively.

There are two main takeaways from this table. First, as expected, the city-size earnings premium for workers transitioning across establishments of similar size goes down and is similar in magnitude to the premium estimated when controlling for the number of co-workers. This result gives us confidence that the main analysis is robust to alternative ways of controlling for co-worker size. Second, if anything, workers transitioning across large establishments benefit less from moving to a larger city than workers moving across medium or small establishments. The coefficient is not significant because the decreased sample size results in a less precise estimate. However, it is reassuring that it is close in magnitude to the coefficient using the full sample.

This exercise addresses the concern that the city-size earnings premium may be heterogeneous across establishment sizes. For example, if more productive establishments are larger and benefit more from

agglomeration economies, then one could expect larger establishments to offer a higher city-size earnings premium than small- and medium-sized establishments. If this were the case, one would expect that a worker moving from a large establishment in a small city to a large establishment in a large city would experience a larger increase in earnings compared to a worker moving from a small establishment in a small city to a small establishment in a large city. However, that is not what we find—workers moving across small establishments experience, if anything, a larger city-size earnings premium.

It is worth noting that this result is consistent with the mover analysis presented in Section B.3 of the Appendix. There, we computed the percentage increase in earnings from moving from a small to a large city while simultaneously transitioning across the three establishment-size categories. The diagonal of Panel b in Table B.5 shows a similar average increase in earnings for those workers transitioning across large (15 percent), medium (17 percent), and small establishments (19 percent) when moving to one of the four largest cities in Spain.

B.5 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 have 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 3.3.

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 (1), but this time allowing the coefficient on the log number of co-workers to vary across cities. Specifically, we run the

regression

$$\ln(w_{it}) = \alpha_{c(i,t)} + \delta_t + \mu_i + \beta_{c(i,t)} \ln(\text{co-workers}_{it}) + x'_{it}\psi + \epsilon_{it}, \tag{5}$$

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

$$\beta_c = \gamma \ln(\text{city size}_c) + u_c. \tag{6}$$

We report the results of these regressions in Table B.7. 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 from 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. Finally, Column 5 repeats the regression in Column 4 but excluding the largest 5 cities. The coefficient is virtually unchanged although significance is reduced.

The within-city co-worker earnings premium is 0.34 ($= 0.49 \times \ln(2)$) 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, 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 2 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 panel 2, column 3 of Table B.1.

Table B.7: Co-workers Earnings Premium and City Size

	(1) Ln. Earn	(2) β_c	(3) Ln Earn.	(4) β_c	(5) β_c
Ln City Size		-0.0041		-0.00491	-0.00490
		(0.0027)		(0.00188)***	(0.00318)
City FE	Y		Y		
Worker Fixed Effects	N		Y		
Controls	N		Y		
N	7,308,794	76	7,308,794	75	70
R^2	0.247	0.025	0.449	0.065	0.034

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. Column (5) excludes the largest 5 cities from the regression in Column (4). Columns (4) and (5) both exclude an outlier observation, Torrevieja, which had a co-worker earnings premium of 0.19, which is more than 5 standard deviations above the average. 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<0.01.

B.6 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 into 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.

The number of co-workers could play a role in 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 also grows faster in larger cities, then over time 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.6.1.

Second, establishment size could also play a role in making experience accumulated anywhere more valuable in large cities. If experience accumulated anywhere is more valuable when working in larger establishments, this could explain part of the reason why the coefficient on experience is larger when the workers are located in larger cities where they are more likely to work in a larger establishment. We test for the quantitative importance of this channel in the second subsection B.6.2.

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, while we do observe the cities where the experience was accumulated, we do not observe the number of co-workers throughout the labor history of individuals.

B.6.1 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 (2) with log co-workers as the dependent variable instead of log earnings. The results are presented in Table B.8.

Table B.8: 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, where 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. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

We find that the elasticity of the number of co-workers with respect to city size is 0.2928 at the time of the 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 in the number of co-workers 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 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.

B.6.2 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 (2) 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.9.

Table B.9: 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, where 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. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

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 the number of co-workers but without controlling for the fact that experience may be valued differently depending on the number of co-workers were 0.0189 in the short-term and 0.0355 in the medium-term. The changes in both the short- and medium-term premia 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, the number of co-workers does not grow much faster in larger cities coupled with the lower co-worker earnings premium in large cities. Second, 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.