Spatial Wage Disparities: Do Firms and their Organization Matter?*

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Abstract

This paper provides evidence in favor of a new mechanism that explains the differences in the dispersion of wages across spatial areas: differences in the way firms organize production. Using French matched employer-employee data, I conduct my analysis on manufacturing firms and I emphasize four results. First, the majority of the dispersion in wages is within areas and within firms. Second, there is greater wage dispersion in firms operating in denser areas. Third, firms in denser areas organize with a greater number of layers. And fourth, approximately 21.7% to 46.4% of the relationship between the density of areas and the wage dispersion in firms is accounted for by differences in the way firms organize production.

KEYWORDS: firm organization, density, regional disparities, wages.

JEL Codes: D22, J31, L11, L22, L23, J24, R12.

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1 Introduction

In urban economics it is well-known there is a spatial dimension to wage inequality, with there being greater inequality in denser areas. This fact has been generally attributed to a greater demand for high-skilled workers in denser areas (Baum-Snow and Pavan (2013) and Baum-Snow et al. (2017)) and to the sorting of workers across space (Combes et al. (2008), Combes et al. (2012) and Diamond (2016)). It is less widely recognized in the urban literature, however, that a substantial share of the dispersion in wages is within firms.[1] For instance, in French manufacturing industries and in the year 2004, approximately 71% of the variation in log hourly wages within areas is within firms. Similar patterns are also observed using other measures of earnings, implying the structure of wages within firms is also important for understanding differences in the distribution of wages across spatial areas.

In this paper, I examine how the dispersion of wages within firms varies with the density of areas. Motivated by the recent literature on organizational hierarchies (Garicano (2000), Caliendo and Rossi-Hansberg (2012) and Friedrich (2015)), I also provide empirical evidence in favor of a new mechanism that explains differences in the dispersion of wages across areas. Namely, the argument of the paper is that one reason for the greater inequality observed in denser areas is firms in denser areas organize with more hierarchical layers. This argument is based on my empirical findings that a substantial share of wage dispersion is within firms, that this dispersion increases with the density of areas, that firms in denser areas organize with a greater number of layers, and that dispersion is greater in firms with more hierarchical layers. My analysis also reveals that this mechanism is important. Differences in the way firms organize production accounts for approximately 21.7% to 46.4% of the relationship between the dispersion of wages within firms and the density of areas. To the best of my knowledge, this mechanism has not been explored in the recent urban literature examining spatial wage disparities.

The results in this paper are interesting for many reasons. First, along with other body of work, they provide additional evidence to the claim that understanding firms and their organization is important for understanding economic outcomes (Rosen (1983) and Garicano and Rossi-Hansberg (2014)). More precisely, the results in this paper illustrate that differences in the way firms organize production account for a meaningful share of the observed dispersion in wages across areas. Second, the results in this paper shed additional insight into the nature and

[1] In this paper, even though they are synonymous, because there are normative implications associated with the term wage inequality, I instead refer to the same outcome using wage disparities.

sources of wage disparities. The majority of research on wage inequality has mainly focused on skill-biased technological change, labor market institutions, urbanization, and international trade (Katz and Autor (1999) and Acemoglu and Autor (2011)). This study provides evidence that how firms adapt their organizational structure to their economic environment is also an important part of the story. And third, the findings in this study are also of interest from a policy perspective. A great amount of resources have been devoted to understanding and reducing the amount of inequality in local communities and in countries. The results in this study suggest, that whether governments are effective in their goals may also depend on how firms adjust their organizational structure in response to the new policies.

The organization of firms provides a new way to understand the relationship between the density of areas and the dispersion of wages across areas. Empirically, firms have a hierarchical structure: they organize their workers into layers of different sizes, with the property that higher layers contain fewer workers earning greater wages. Knowledge-based management models emphasizing organizational hierarchies argue that the number of layers in firms has an effect on the structure of wages within firms (Garicano (2000) and Caliendo and Rossi-Hansberg (2012)). Consider what happens when a firm introduces a new layer to its organization. In theory, an additional layer increases the wages of workers at the top of the hierarchy, however it decreases the wages of all workers in the remaining layers of the firm, because their knowledge is now less important for production. As a result, the distribution of wages is more unequal in firms with more layers. Using French and Portuguese matched employer-employee data, Caliendo et al. (2012) and Caliendo et al. (2015a) provide empirical evidence supporting this theoretical prediction.

Knowledge-based management models with heterogeneous firms also argue that the optimal number of layers in firms varies with the economic environment (Garicano (2000), Garicano and Rossi-Hansberg (2006), Antras et al. (2006), Caliendo and Rossi-Hansberg (2012) and Spanos (2017)). Current models in this literature have established that trade costs, international competition, market structure and market size determine the organizational decisions of firms. Consistent with this class of models, this study examines the effect the density of areas has on the organization and the amount of wage dispersion in firms.

The main dataset used in this study is the Déclarations Annuelles des Données Sociales (DADS), which is a matched employer-employee dataset constructed from mandatory tax reports. From the DADS, I retain information on workers from manufacturing firms operating in mainland France in the year 2004, and measure the amount of wage dispersion within firms.

Using information from the DADS, I also measure the number of layers in firms with the method developed by Caliendo et al. (2015b). This method groups workers into one of four possible hierarchical layers - ordinary workers, supervisors, senior managers, and owners who receive a salary from firms and corporate officers - and because not every firm employs workers in every layer, there are four types of firms in the data: one-layer, two-layer, three-layer and four-layer firms.

My empirical strategy exploits spatial variation across employment areas, which correspond to travel to work areas. To begin my analysis, I combine ideas from both the labor and urban literature and assess the extent the dispersion in wages in manufacturing is within employment areas and within firms. From this empirical exercise, I first find that the majority of the observed dispersion in wages is within employment areas. And second, I find that within employment areas the majority of the variation in wages is within firms. These results are consistent with findings from the labor literature (see for example Davis and Haltiwanger (1991), Lazear and Shaw (2009), Akerman et al. (2013), Barth et al. (2016) and Song et al. (2017)) demonstrating that the majority of wage inequality is within firms. They also imply the structure of wages within firms is important for understanding differences in the amount of wage dispersion across employment areas.

In view of these findings, I then turn to regression analysis to assess the relationship between the density of employment areas, the number of layers and the degree of wage dispersion in manufacturing firms. The evidence leads to the following conclusions. First, there is greater wage dispersion in firms operating in denser employment areas. For instance, a 1% increase in density is associated with a 11.3% increase in the variance of log hourly wages in firms. Second, I conclude that firms in denser employment areas organize with a greater number of layers. For example, a 1% increase in density is associated with an additional 0.047 layers in firms. And third, I find there is greater wage dispersion in firms with more layers. For example, controlling for the industry and the area of firms, an additional layer is associated with a 111% increase in the variance of log hourly wages within firms. Together these magnitudes imply differences in the organization of firms accounts for roughly 31% of the increasing relationship between density of employment areas and the variance of log hourly wages in firms.

Moreover, these findings are robust. To assess the validity of my results, I examine the same relationships using different sample of firms, different measures of within-firm wage and earings dispersion, and I also control for the characteristics of employment areas and of firms. In addition, following Ciccone and Hall (1996), Combes et al. (2008) and Combes et al. (2010), in several specifications I also instrument for the density and the local characteristics of employment areas using historical values, because one common concern in the urban literature is that density and local characteristics are endogenous. I also report results from measures of dispersion constructed from residual wages, because another concern with the analysis is individuals sort into areas and into firms (Combes and Gobillon (2015) and Chade et al. (2017)). In every case, the conclusions remain the same. Overall, my analysis reveals that spatial differences in the way firms organize production accounts for approximately 20.8% to 55.0% of the relationship between the wage and earnings dispersion within firms and the density of employment areas.

This paper contributes to a literature exploring the nature and sources of spatial wage disparities, reviewed in Combes and Gobillon (2015). Using different approaches, a number of empirical studies have documented there is greater wage inequality in denser areas, implying the benefits from agglomeration are not equally shared between all actors of production (see for example Yorukoglu (2002), Wheeler (2005), Combes et al. (2012), Baum-Snow and Pavan (2013), Moretti (2013), Lee et al. (2016), Baum-Snow et al. (2017)). My main contribution to the current literature is to provide evidence in support of a new mechanism that explains the greater wage dispersion observed in denser areas. I also document new empirical patterns that may be of interest for future theoretical and empirical work in urban economics. In particular, two important findings emerging from this study are that the majority of wage dispersion within areas is within firms, and that the dispersion within firms increases with the density of areas. Both findings imply that firms hire different types of workers to perform different tasks within the same firm, consistent with the work from Gennaioli et al. (2013) and Behrens et al. (2014). They also present a challenge to many urban models investigating spatial wage disparities, which mostly abstract from the production structure within firms or assume the same type of workers are employed in firms.

Furthermore, this paper also contributes to a literature on the organization of firms, summarized in Antras and Rossi-Hansberg (2009) and Garicano and Rossi-Hansberg (2014). A growing group of studies have began to demonstrate that the organization of firms has a central role in the study of labor market outcomes, global trade, firm productivity and technological change. The observation that there is greater wage dispersion in firms operating with a greater number of layers has been also documented in other studies (see for example Caliendo et al. (2012) and Friedrich (2015)). The contribution of this paper to the current body of work is to document that differences in the way firms organize production is also important for understanding spatial disparities.

Within this literature my paper is most closely related to Spanos (2017). Extending the knowledge-based management models from Garicano (2000) and Caliendo and Rossi-Hansberg (2012), Spanos (2017) provides both theoretical and empirical evidence in support of the argument that firms in denser areas are more productive because they organize with a greater number of layers. He also examines the implications of his theory on service industries characterized by a strong local demand. The conclusion from his study is that differences in the way firms organize production accounts for 6% to 33% of the productivity gains from operating in denser areas. This paper complements the work in Spanos (2017) in the following ways. First, by documenting that manufacturing firms operating in denser areas also organize with a greater number of layers. And second, by documenting that spatial differences in the organization of firms is also important for understanding spatial wage and earnings disparities.

More broadly, the findings in this paper are also relevant to a large literature investigating the rising wage and earnings dispersion observed in modern economies, reviewed in Katz and Autor (1999), Acemoglu (2002) and Acemoglu and Autor (2011). The prevailing explanations of these trends are changes in the demand and supply for skills and tasks, changes in labor market institutions, and changes in the amount of global trade. Recently, a number of studies have separately emphasized that increasing urbanization and organizational change have an effect on the returns to different factors of production and as a result on the amount of inequality in the economy.[2] This paper demonstrates the ideas from both strands of the literature are related. In particular, this study provides evidence that the density of areas has an effect on the organization of firms and estimates the contribution of each component to the amount of wage dispersion observed in firms.

The remainder of the paper is structured as follows. Section 3 introduces the data used in this study, Section 4 presents the empirical strategy and discusses several identification concerns, and Sections 5 and 6 examine the relationship between density, organization and the degree of wage dispersion in firms. The following section presents the motivating relationships in the data.

[2]For studies that make the argument that urbanization is important, see for example Baum-Snow and Pavan (2013), Moretti (2013) and Baum-Snow et al. (2017). For studies that make the argument that organization change is important, see for example, Garicano (2000), Caroli and Van Reenen (2001), Bresnahan et al. (2002), Garicano and Rossi-Hansberg (2006) and Dessein and Santos (2006)

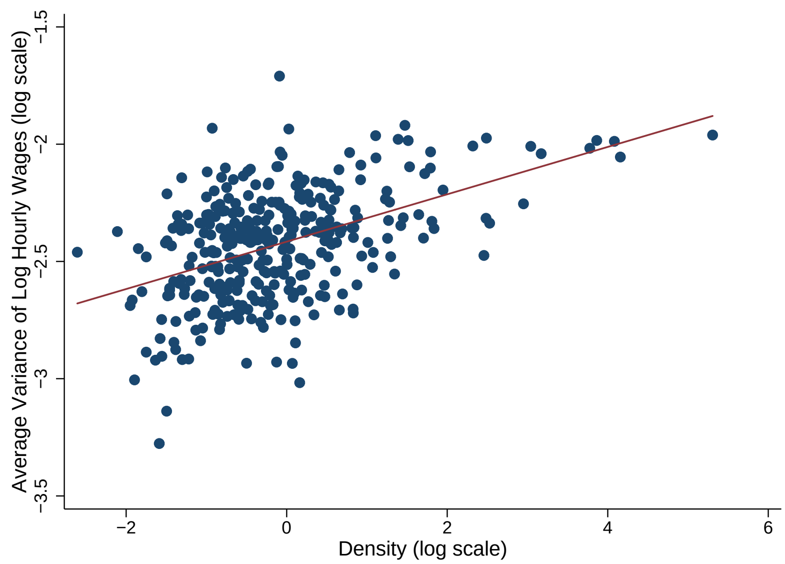


Figure 1: Within-Firm Wage Dispersion & Density

2 Fundamental Relationships in the Data

To motivate the analysis of the paper, I first illustrate the main relationships of interest. There are three variables of interest in this study, the density of employment areas, the number of layers in manufacturing firms, and the degree of wage dispersion in manufacturing firms. For the year 2004, Figures 1, 2, and 3 illustrate how each variable relates to one another. Naturally, from the three variables, we can think of density as the underlying parameter generating the data.

That wage dispersion is greater in denser areas has been documented in other studies (see for example Yorukoglu (2002), Wheeler (2005), Combes et al. (2012), Baum-Snow and Pavan (2013), Moretti (2013), Lee et al. (2016), Baum-Snow et al. (2017)).[3] One important fact that has not received much attention in the urban literature, is that the majority of the dispersion in wages is within firms. For our purposes the relationship of interest is how the wage dispersion within firms varies with the density of employment areas. This is illustrated in Figure 1. Not surprisingly, there is a positive relationship between the average variance of log hourly wages within firms and employment area density. The elasticity is 0.101 (p-value $\approx$ 0.000 and $R^2 \approx 0.219$) which implies that doubling the density of an area is associated with a 7.3% increase in the average variance of log hourly wages in manufacturing firms. In the baseline sample described below, the average variance of log hourly wages in firms located in the first quartile of the employment

[3] In the data, the elasticity of the variance of log hourly wages with respect to density is 0.126 (p-value $\approx$ 0.000 and $R^2 \approx 0.351$) which implies that doubling the density of an area is associated with a 9.1% increase in the variance of log hourly wages.

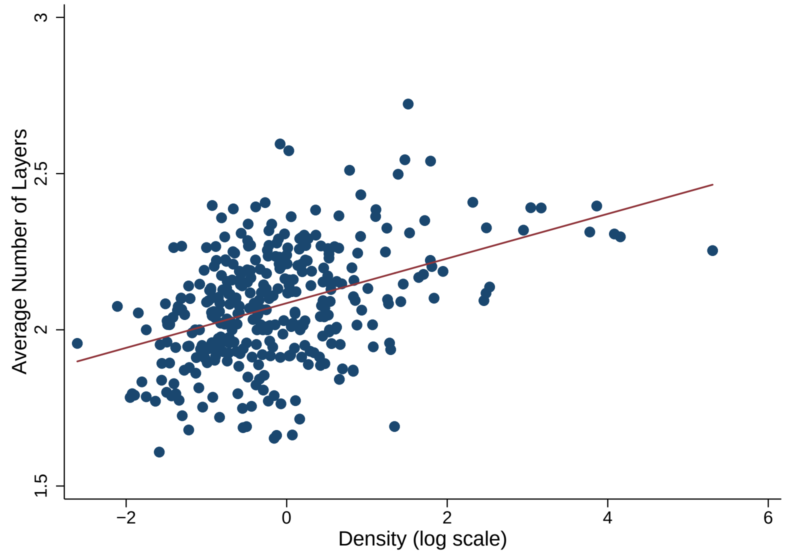


Figure 2: Organization & Density

area density distribution is equal to 0.081, whereas in firms located in the second, third and fourth quartiles, it is equal to 0.087, 0.093, and 0.109, respectively.

Moreover, the way firms organize production is not random across employment areas. Figure 2 illustrates the relationship between the density of employment areas and the organization of manufacturing firms. There is a strong positive relationship between the average number of layers in firms and the density of employment areas. The estimated coefficient on density in Figure 2 is equal to 0.071 (p-value $\approx$ 0.000 and $R^2 \approx 0.173$) which implies that doubling the density of an area is associated with a 0.049 increase in the average number of layers in manufacturing firms. A similar result has also been documented by Spanos (2017) for service industries. Unlike Spanos (2017), who examines the implications of firm organization on the productivity gains from operating in denser areas, this study examines the extent organization is important for understanding the disparity in wages across areas.

More precisely, this study shows that the relationship in Figure 1 is an implication of the hierarchical organization of firms. This is documented in Figure 3, which illustrates that across employment areas, average wage dispersion in firms increases with the average number of layers in firms. The estimated semi-elasticity is equal to 0.996 (p-value $\approx$ 0.000 and $R^2 \approx 0.630$), implying that a 0.049 increase in the average number of layers in firms is associated with a 4.9% increase in average variance of log hourly wages in firms. This represents approximately 67% of the increase in the dispersion of wages from a doubling of density in Figure 1, and suggests that

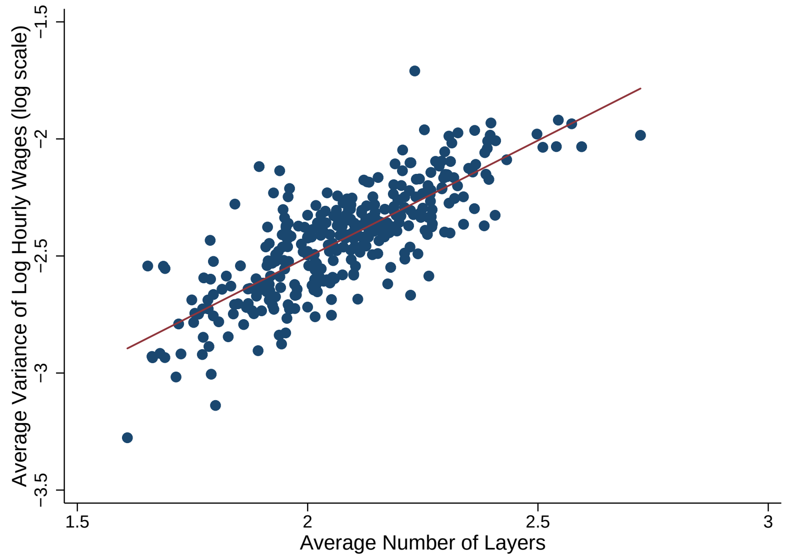


Figure 3: Within-Firm Wage Dispersion & Organization

differences in the way firms organize production is important for understanding the within-firm variation in wages, and the spatial wage disparities.[4]

Naturally, the findings in this section are a rough approximation, because the analysis does not control for the industry of firms nor the characteristics of employment areas. The remaining objective of this study is threefold. First it is to examine the relationship between local density and the wage disparities within firms. Second it is to examine the relationship between local density and the number of layers in manufacturing firms. And third, the objective of this study is to assess how important is organization to understanding spatial within-firm wage disparities, while accounting for confounding economic factors and addressing other identification concerns.

3 Data & Descriptive Statistics

3.1 Data Sources

The main dataset used in this study is the Déclarations Annuelles des Données Sociales (DADS), which is constructed from mandatory tax reports. By law, every year each firm operating in France is required to report information on employees who earn a salary from the firm, and this

[4]Accounting for the density of areas, as done below, yields similar results. That is, regressing the log of the average variance of log hourly wages in firms on the organization of firms and the density of areas yields a point estimate on organization equal to 0.909 (p-value ≈ 0.000), implying that spatial differences in the organization of firms accounts for roughly 63% of the increase in the dispersion of wages from the doubling of the density of an area.

information is collected by the French National Statistical Institute for Statistics and Economic Studies (INSEE).

The information in the data is reported at the level of a job, which corresponds to one or several periods of the same worker in the same establishment of a firm. Each worker has a unique identifier which only remains with her for two consecutive years, while each firm and establishment have a unique identifier which are the same in different datasets and throughout the years. For each job of the year, the DADS reports information on the identity of the firm, the identity of the establishment, the identity of the worker, the type of contract, the annual salary, the total number of hours and days worked, and the worker's occupation within the firm.[5] In addition, for each worker the DADS also reports some basic information on her characteristics, such as her age and gender. The data also contain limited information on firms, such as the main industry of firms, as well as the municipality (*commune*) of each establishment.

The analysis is conducted at the level of firms instead of establishments, because recent theories emphasize organizational decisions are made by firms. From the DADS, I only retain workers between the ages of 16 to 65, with ordinary jobs in mainland France and non-missing information. For each worker, I aggregate her salary, hours and days worked at the level of her firm, and because a number of workers hold jobs in multiple firms, I only retain the employment with the highest salary.[6] To avoid any reporting issues associated with service firms, I simply focus my analysis on manufacturing firms with at least 4 employees. In the Appendix, I also report results of a robustness test, that relaxes the last restriction and undertakes the analysis on all manufacturing firms in France.

For the most part, in this study my measures of wage dispersion are based on hourly net wages, which is the salary a worker receives after social security deductions divided by the number of hours worked in the firm. Hourly net wages seems more appropriate because it is probably correct for measuring the returns to skill and it is closely associated with individuals' disposable income. A consensus on the best sources of income to base measures of wage dispersion does not exist in the literature, and most studies are limited by the information available in the data (Ar-

[5]The information on the type of contract a worker has with the firm is the following: the type of job, that is whether it is an ordinary job, an internship, an apprenticeship or government assisted employment, and whether the job is full-time or part-time.

[6]In case of a tie, then I retain the employment spell with the greatest number of hours worked. In case of another tie, I randomly select a firm. In addition, there are a number of workers that hold multiple jobs within a single firm with different occupational codes. For worker with multiple jobs within a single firm and with different occupational codes, I allocate to them the layer with the greatest salary. In case of a tie, I allocate the layer with the greatest number of hours worked, and in case of another tie, I randomly select one of the layer. Further below, I discuss how I assign workers into layers of firms using occupational codes.

mour et al. (2013)). To assess whether my findings are robust to other measures of hourly wages, I also show results using gross hourly wages. As an additional check I also examine whether my findings are robust to measures of income, such as total gross earnings and total net earnings, because income rather than wages has generally been the focus of study and recent empirical work has began to analyze the extent the dispersion in earnings takes place within and across firms (Barth et al. (2016) and Song et al. (2017)).

I also combine information from the DADS with several administrative sources provided by INSEE to control for the additional characteristics of firms and employment areas. First, I use the French Customs data, which contains annual transactions at the firm-product-destination level, to identify exporters in my sample. Second I use balance sheet data, from the Fichier Complet Unifié de Suse (FICUS), to gather some additional information on the characteristics of firms. From this dataset I obtain information on the level of capital in firms, on whether firms are an independent entity or whether they belong to a business group, as well as on the legal structure of firms. And third, from the Recensement de la Population (RP), I acquire information on the local characteristics of municipalities. The RP is a septennial census and contains demographic information on all individuals residing in mainland France. Using the years 1968 and 1999, for each municipality I obtain information on the share of unemployed and the share of foreign-born individuals residing in the area, as well as the fraction of the local population over the age of 25 with a university degree.

3.2 Constructing the Organization of Firms

An important property of the occupational codes in the DADS is they contain information on the hierarchical ranking between positions in firms. To measure the number of layers in firms I use the method put forth by Caliendo et al. (2015b), which assigns each employee into a hierarchical layer using the first-digit of her occupational code. In the data, there are five occupations that are related to non-agricultural workers, which are grouped into four occupational categories in a way that is consistent with the theoretical idea of a layer in firms. Occupational codes 2, 3, 4 each form a specific category. Occupational code 2 contains workers with the greatest authority in firms: owners earning a salary from the firm and corporate officers. Occupational code 3 is composed of senior managers and directors, while occupational code 4 contains supervisors and employees with a greater responsibility than ordinary workers. Finally, occupational codes 5 and 6, which are brought together into one occupational category, contain ordinary production and administrative workers.

Following Caliendo et al. (2015b), my measure of the total number of layers in firms is based on the hierarchical ranking between the occupational categories in firms. Specifically, in this study firms with workers in ℓ occupational categories are simply measured as ℓ-layer firms. For instance, in my analysis firms with workers in occupations 2 and 5, or in occupations 2 and 3, are measured as two-layer firms. Caliendo et al. (2015b) further provide evidence that this method of constructing the number of layers in firms is consistent with recent theoretical models on organizational hierarchies.[7] In the Appendix, I also present similar evidence (see Table B1). As will be shown further below, there are four different types of firms in the data - one-layer, two-layer, three-layer and four-layer firms - because not every occupational category is present in every firm.

3.3 Geographical Decompositions

In the data, the location of firms is reported at the municipal level (*commune*). To cover all of mainland France, I aggregate municipalities to the level of employment areas (*zones d'emploi*). Employment areas are based on individual commuting patterns and are geographical spaces where the majority of individuals reside and work within the area. In total, there are 341 employment areas within mainland France and each municipality belongs to a single area. The advantage of using employment areas over other geographical decompositions of mainland France, such as urban areas or metropolitan areas, is that employment areas delimit local labor markets, and so they better reflect local economies within France.

Moreover, I measure the size of areas using population density, which is equal to the number of individuals residing in an employment area in the year 1999 divided by its surface area, measured in hectares squared. Population density, hereafter simply referred to as density, seems to be the more appropriate measure because it better reflects the local concentration of economic activity. Different measures of the size of employment areas, such as employment density, have also been used in urban studies analyzing worker wages (Combes et al. (2008), Combes et al. (2010) and Combes et al. (2012)). In unreported results, I have also conducted my analysis using other measures of the size of employment areas, such as employment density, manufacturing employment density, and total population. The correlation between these variables and density

[7] More precisely, they show the distribution of wages in occupations 5 and 6 are similar, that higher layers contain fewer workers who earn greater wages. Additionally, they show that when firms re-organize and add a new layer, the number of workers in existing layers increases and wages in existing layers decrease. Conversely, they also show that when firms remove an existing layer, the number of workers in the remaining layers increases along with their wages.

Table 1: Summary Statistics of Organizations

	Number of Firms	Average Number of Workers	Average Number of Hours	Average Log Hourly Wage	Average Variance of Log Hourly Wages	Average 95-5 Log Hourly Wage Gap
Total Number of Layers						
One-Layer	21,399	6.95	7,784	2.00	0.03	0.40
Two-Layer	21,403	9.97	12,995	2.17	0.09	0.77
Three-Layer	17,694	18.37	25,913	2.32	0.15	1.12
Four-Layer	6,487	34.10	50,016	2.38	0.20	1.32

Notes: Summary statistics of firms grouped by their number of layers.

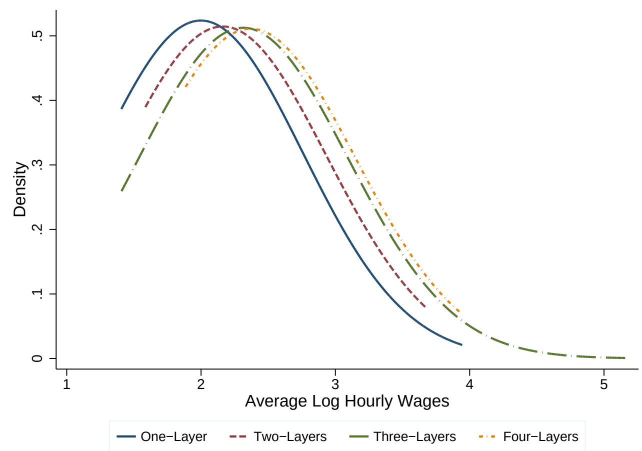
is 0.975, 0.615 and 0.635, respectively, and in every case, the conclusions from the analysis remain the same (results are available upon request).

That the analysis is undertaken at the level of firms presents one additional difficulty. In the data there are a number of firms operating establishments in multiple areas. This creates an issue for my analysis since it is impossible to allocate these firms to a single area. In addition, Antras et al. (2008) argue one reason firms organize with a greater number of layers is because they operate establishments in different locations. Understanding these firms and how their decisions are influenced by the density of employment areas is beyond the scope of this paper. In my baseline estimates I therefore restrict my analysis to independent firms with all of their workforce in a single employment area.[8] To assess whether my findings are robust to this restriction, I also assign firms to the area with the greatest amount of labor employed, measured using the number of hours worked. In the Appendix, I also report results from another robustness exercise that retains all manufacturing firms with at least 90% of their labor in a single area.

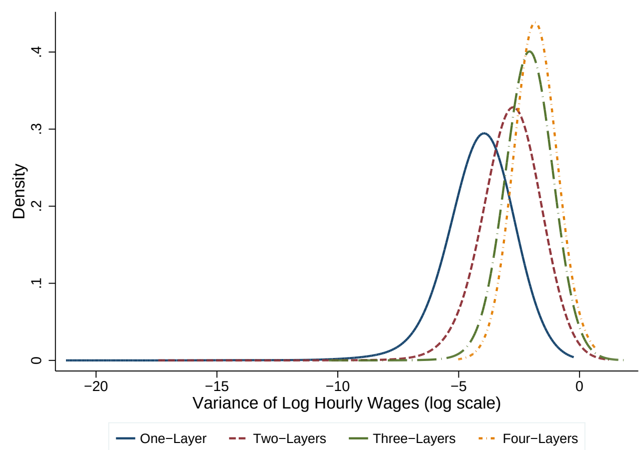
3.4 General Descriptive Statistics

I now provide descriptive statistics from my baseline sample. For the year 2004, there are 341 employment areas, the average density of an area is 2.63 inhabitants per hectare squared, and the median density is 0.743 inhabitants per hectare squared. Furthermore, the sample is composed of 908,365 workers employed in 66,983 manufacturing firms, and 63,338 firms in the baseline sample are single establishment firms. On average 196 firms operate in an area, and the correlation

[8] I remove firms belonging to a business group because I do not have information on the firms that make up the group and their location. In addition, it is unclear whether firms that are part of a business group behave as independent firms. Cestone et al. (2017) provide evidence to the contrary, and show that firms belonging to a business group share workers as well as provide insurance to their workers against negative shocks. Despite these concerns, as a robustness check, I also report results in the Appendix from all manufacturing firms that operate in a single area and have at least 4 employees.



(a) Average Log Hourly Wages



(b) Variance of Log Hourly Net Wages (log scale)

Figure 4: Distributions of Wages Across Organizations

between the density of employment areas and the number of firms is equal to 0.865.

Table 1 groups firms by their organization and reports descriptive statistics. Roughly 31.9% of firms in the baseline sample are one-layer firms, 31.9% are two-layer firms, and 26.4% and 9.7% organize production with three and four layers, respectively. Table 1 also reports that firms with a greater number of layers have different observable characteristics: they on average employ more workers, pay higher hourly wages and the distribution of wages in firms with a greater number of layers has a greater spread. To emphasize the differences in the structure of wages in firms, figures 4a and 4b illustrate the kernel density of the distribution of average log hourly net wages and the variance of log hourly net wages across firms with the same organization. Consistent

Table 2: Distribution of Organizations across Employment Areas

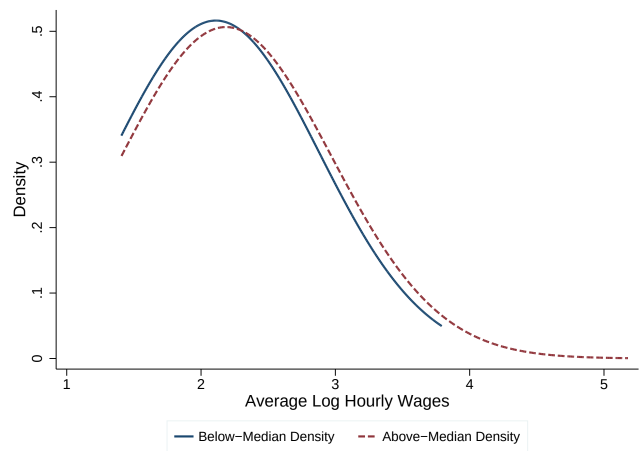
	Number of Firms	Average Number of Layers	Distribution of Organizations: Percent One Layer	Percent Two Layers	Percent Three Layers	Percent Four Layers
All	66,983	2.14	0.319	0.319	0.264	0.097
Below Median	16,337	2.04	0.366	0.320	0.227	0.087
Above Median	50,646	2.17	0.305	0.319	0.276	0.100

Notes: Employment areas are grouped into two categories: above the median density of areas and below the median density of areas.

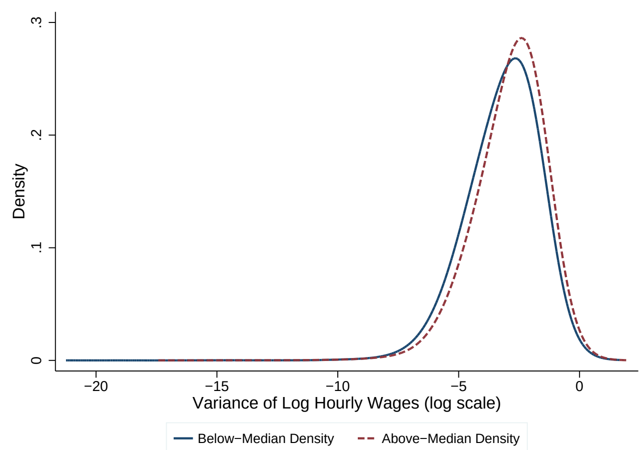
with previous findings from the literature on the organization of firms (see for example Caliendo et al. (2012) and Friedrich (2015)), the figures demonstrate there is a ranking of distributions, with firms organizing with a greater number of layers paying on average greater wages and having a greater variation in their distribution of wages.

The remaining analysis of this subsection separates employment areas into two groups, above-median and below-median density, and reports some basic patterns on firms. Table 2 presents evidence suggesting that the organization of firms is different across areas. On average firms in employment areas with above-median density organize production with 2.17 layers, while in areas with below-median density firms on average operate with 2.04 layers in their organization. In addition, Table 2 further illustrates that denser areas have a greater share of three-layer and four-layer firms. Consistent with the findings from Spanos (2017), this evidence suggests there is a stochastic ordering of distributions, with the distribution of organizations in denser areas first-order stochastically dominating the distribution in less dense areas. In a section below, I formally examine whether this is the case.

Furthermore, figures 5a and 5b plot the kernel density of two moments of the distribution of wages, from firms operating in employment areas with above-median and below-median density. The main takeaway from the figures is the structure of wages within firms is also different across areas. In both figures there is again a ranking of distributions, with firms operating in denser areas paying on average greater wages and having a greater variation in their distribution of wages. The argument of the paper is that this observed pattern results from the differences in the way firms organize production. Moreover, figures 5a and 5b are also consistent with empirical studies in the urban literature, which document greater wages and greater dispersion in denser areas (see for example Combes et al. (2010)).



(a) Average Log Hourly Wage



(b) Variance Log Hourly Wages (log scale)

Figure 5: Distribution of Net Wages Across Areas

4 Identification Strategy

This section presents the general empirical strategy of the study, describes the variables used in the analysis, as well as discusses several identification concerns.

4.1 General Equation

My analysis is conducted on the year 2004 and relies on cross-sectional variation in the density of employment areas. To assess how firms organize production across areas, and how the wage dispersion within firms varies with the density of areas, I estimate equations which have the following form:

$$y_{j,a(j)} = \alpha_0 + \alpha_1 D_{a(j)} + \alpha_2 E_{a(j)} + \epsilon_{j,a(j)}, \tag{1}$$

where $y_{j,a(j)}$ is an outcome variable from firm j operating in employment area $a(j)$, $D_{a(j)}$ is the natural logarithm of the density of area $a(j)$, and $E_{a(j)}$ represents additional controls of the characteristics of employment areas described below.

Equation (1) illustrates the general structure of my empirical approach. Depending on the relationship being examined, the dependent variable, $y_{j,a(j)}$, is either equal to the number of layers in firms, or a measure of the wage disparities in firms. The remaining subsections present the additional controls and discuss identification concerns.

4.2 Employment Area Controls

To isolate the effect of density, I control for local characteristics that may determine the density of areas and the outcomes of firms. The economic activity of surrounding areas may have this effect. For example, employment areas with good market access may be attractive to workers, and firms operating in these areas may organize with more layers because of greater product demand. For this reason, in my estimation I control for the market potential of areas, constructed as the sum of the density of neighboring employment areas weighted by distance.[9]

The industrial composition of employment areas may also be important. It is quite possible that areas with greater industrial variety attract workers allowing for greater knowledge spillovers, which most likely decreases the costs associated with hiring and training workers and the number of layers in firms. To account for the industrial composition of employment areas, I follow Glaeser et al. (1992) and Combes et al. (2008) and control for the degree of economic diversity of areas, using the inverse of a Herfindahl industry-employment index.[10]

Differences in the endowments of employment areas may also determine the size of areas and the outcomes of firms. For instance, areas near the sea may be attractive places to live, reducing the costs of a unit of labor and the number of layers in firms. To account for the endowments of areas, I follow Combes et al. (2008) and control for the share of municipalities in each area with the following attributes: sea shores, mountains, lakes and water, as well as cultural heritage. Each of these attributes are determined by the geography and the history of municipalities, and

[9]To be precise, the market potential of area a is equal to: $\sum_{a' \neq a} density_{a'} / d(a, a')$.

[10]The inverse of the Herfindahl industry-employment index of an area a is equal to: $Emp_a^2 / \sum_{k \in a} Emp_{a,k}^2$, where $Emp_{a,k}$ denotes the number of hours in industry k and area a, and $Emp_a = \sum_{k \in a} Emp_{a,k}$.

so they are independent of firms. For this reason, throughout my analysis I consider these local endowments to be exogenous variables.

4.3 Demographic Composition of Employment Areas

Recent studies have shown the distribution of workers is not homogeneous across space. Individuals sort into areas with a greater share of low and high skilled workers sorting into denser areas. In addition, studies in labor economics argue there is also a systematic pattern in the types workers employed in firms (see Chade et al. (2017) for a literature review). These findings raise another concern. Differences in the composition of workers across areas and firms may have an effect on the outcomes examined in this study.[11]

To address this concern, I do the following. First, I control for a number of demographic characteristics of employment areas that research has demonstrated are correlated with density and may have an effect on the outcomes of firms. It has been established in the economics literature that high-skilled individuals locate in denser areas (Glaeser and Mare (2001), and Combes et al. (2008)). A greater supply of high-skilled individuals may increase the supply of workers competing for supervisory and managerial jobs, decreasing the costs of hiring knowledgeable workers and the disparities in firms. On the other hand, it has also been documented in the labor literature that foreign-born individuals tend to locate in denser areas (see for example Card (2009)). These individuals most likely compete for jobs in the lowest layers of firms, decreasing the costs of hiring low-skilled workers and increasing the disparities in firms. In a similar manner, a greater share of unemployed individuals may also affect the outcomes of firms. In several specifications I therefore also control for the share of foreign-born individuals residing in an area, the fraction of the local population over the age of 25 with a university degree, as well as the share of unemployed individuals in a local area.

There are other differences in individual attributes that are also important determinants of earnings. Including additional employment area controls, however, raises collinearity concerns because nearly all of the demographic characteristics of areas are strongly correlated with density. Instead of saturating my specification and directly controlling for these attributes, when examining the disparity in firms I also report results from measures of dispersion constructed from residual wages.

I compute residual wages using two methods. The first controls for differences in observable

[11] In the urban literature, when examining earnings, differences in the composition of workers across areas is also referred as the endogenous labor quality problem (see Combes et al. (2012)).

characteristics reported in the DADS. From this method measures of wage dispersion are constructed from the residuals of a Mincerian log hourly wage regression with age effects interacted with gender, an indicator variable for whether the worker has a full-time job interacted with gender, and with industry-area fixed effects. The regression is estimated for the year 2004, on individuals in the baseline sample, and measures of dispersion constructed from this method are labeled Residual Wages I.[12]

The wage regression from Residual Wages I accounts for observable characteristics that are available in the DADS, however, there are also other characteristics that determine wages, such as education. In addition, there are unobservable worker attributes, such as ambition, discipline and innate ability, that are observable to the firm but not the econometrician, and that are also important determinants of wages (Combes et al. (2008) and Bacolod et al. (2009)). To account for both concerns, I use the longitudinal dimension of the data and compute a second measure of residual wages. This measure obtains residual wages from a log hourly wage regression with a cubic age polynomial interacted with gender, an indicator variable for whether the worker has a full-time job interacted with gender, industry effects, area effects, and with worker fixed effects. The wage regression is estimated over the period 2003 to 2004, on individuals employed in firms in the baseline sample that are observed for both years. Measures of dispersion derived from this method are labeled Residual Wages II.

4.4 Instrumental Variables

That density is endogenous is a common concern of urban studies. The same concern is also present in this paper for two separate reasons. First, despite the additional controls, there may be omitted variables in equation (1) that determine both the density of employment areas and the outcomes of firms, such as local shocks. And second, density and the outcomes of firms may be determined simultaneously. For instance, it is possible that firms producing with a greater number of layers demand additional or high-skilled labor and attract more workers to the area.

To limit these concerns, density is measured in the year 1999. Additionally, I also follow Ciccone and Hall (1996), Combes et al. (2008) and Combes et al. (2010) and instrument for density using historical values from as early as 1831. As argued by Combes et al. (2010) this empirical strategy is reasonable because the instruments are relevant and exogenous. More precisely, the instruments are relevant because many employment areas that where densely populated in the

[12] Residual wages are constructed using hourly net wages.

past are also densely populated today. Furthermore, because the economy and the political institutions in France are different today from the nineteenth and early twentieth centuries, it is reasonable to assume the instruments are exogenous and independent of the outcomes of manufacturing firms in the year 2004 (Combes et al. (2008) and Combes et al. (2010)).

Moreover, the same endogeneity concerns can also be raised for the additional controls. To address this issue, in my analysis I also report results from econometric methods that instrument for the local characteristics of employment areas. As with density, I instrument for market potential with historical measures from as far back as 1831. For the remaining local characteristics of areas I use as instruments similar variables constructed from the RP dataset in 1968. For these variables simultaneity bias should not be of great concern, because it is unlikely firms and workers anticipated the local economic environment in 1999 when making their decisions in 1968. In addition, if local shocks are contemporary, they did not affect the distribution of the population decades ago, or if they are of short duration, omitted variable bias from local shocks should be of minor concern.

4.5 Firm Characteristics

The last concern with the estimation is associated with other attributes of firms. There are firm characteristics, such as the degree of task specialization or selling to foreign markets, that possibly also have an effect on the number of layers and the structure of wages in firms. As a robustness exercise, in the Appendix I also report results from specifications that control for the characteristics of firms. The variables included in the analysis are the following: the size of firms, the number of additional occupations in firms, the export status of firms, the amount of capital and the legal status of firms.

A few more words are warranted for specifications that control for the characteristics of firms. Most heterogeneous firm models argue the outcomes of firms are determined by one or two underlying parameters (see Melitz (2003) and Bernard et al. (2011)). In light of recent theoretical models, interpreting coefficients from specifications with many firm controls is difficult, because it is not easy to understand where the source of variation identifying the estimates is coming from. Moreover, including additional firm controls in the estimation creates endogeneity problems, biasing estimates.

Whether additional firm controls are justifiable depends on ones belief of the underlying process generating the data. Whatever this belief, one thing that is certain is that including firm controls moves the analysis away from a causal analysis and towards a descriptive exercise. To overcome this problem one would need to address the endogeneity problems created from the extra firm controls. More precisely, one would need to understand the production technology of firms, as well as to identify an exogenous source of variation that only operates through one specific channel. To my knowledge, very few empirical papers have managed to address this issue, and this is also beyond the scope of this study.

5 Wage Disparities Across Employment Areas

Having presented the main descriptive statistics of the data and discussed the identification strategy, this section turns to examining the structure of wages in manufacturing firms operating in mainland France. The analysis progresses in two steps. First, to motivate my analysis, I show that a substantial share of the variation in wages in manufacturing is within firms. And second, because it has not been documented in the urban literature, I show there is greater dispersion in the wages of firms operating in denser employment areas.[13]

5.1 Wage Dispersion: Within vs Across Firms

Research in urban economics has documented there is a spatial dimension to wage inequality, with there being greater inequality in denser areas (see Glaeser et al. (2009) and Baum-Snow and Pavan (2013)). Additionally, a group of studies in labor economics have established that, at a given moment in time, a substantial share of the dispersion in wages is within firms (see Davis and Haltiwanger (1991), Lazear and Shaw (2009), Akerman et al. (2013), Barth et al. (2016) and Song et al. (2017)). This subsection combines ideas from both strands of economic literature and documents the extent the observed dispersion in wages takes place within employment areas, and within firms. More precisely, Table 3 decomposes the variance of wages, or the total variation in wages, into the following components:

[13]At this point, it is important to emphasize that the analysis is based on measures of wage inequality which are different from measures income inequality in the following ways. First, beyond earnings, incomes include other sources of individual revenues, such as the returns to capital investments and rents. Second, the set of individuals included in both measures is different. Measures of wage inequality are based on the set of employed individuals, while measures of income inequality include the unemployed as well as individuals who are retired or not active in the labor market. And third, measures of income inequality are based on where individuals live, whereas measures on wage inequality are based on where individuals work. Papers that examine the spatial aspect of income inequality are the following: Glaeser et al. (2009) and Florida et al. (2014).

Table 3: Variance Decomposition Analysis

	Number of Observations	Total Variation	Across Areas	Within Areas	Within Areas Across Firms	Within Areas Within Firms
All Workers						
Log Hourly Net Wages						
All Firms	3,979,958	0.201	0.025	0.176	0.055	0.121
Sample	908,365	0.157	0.007	0.150	0.044	0.106
Sample: Single-Establishment	841,702	0.159	0.007	0.152	0.044	0.108
Full-Time Workers						
Log Hourly Net Wages						
All Firms	3,436,870	0.199	0.026	0.173	0.054	0.119
Sample	744,526	0.154	0.007	0.147	0.042	0.105
Sample: Single-Establishment	692,492	0.155	0.007	0.148	0.042	0.106
Full-Time Male Workers						
Log Hourly Net Wages						
All Firms	2,496,814	0.205	0.026	0.179	0.057	0.122
Sample	536,609	0.162	0.007	0.155	0.046	0.109
Sample: Single-Establishment	503,213	0.163	0.008	0.156	0.046	0.110
All Workers: Sample						
Residual Wages I	908,365	0.107	0.000	0.107	0.016	0.091
Residual Wages II	615,899	0.012	0.000	0.012	0.004	0.008
Log Hourly Gross Wages	908,365	0.166	0.035	0.131	0.019	0.112
Log Net Earnings	908,365	1.455	0.284	1.171	0.196	0.975
Log Gross Earnings	908,365	1.438	0.279	1.159	0.193	0.966

Notes: Variance decompositions for the year 2004. All Firms refers to all manufacturing firms. Sample refers to firms in the baseline sample. Sample: Single-Establishment refers to all firms in the baseline sample with only one establishment. Full-Time Workers refers to the set of workers that have full-time jobs in firms. Full-Time Male Workers refers to set of male workers that have full-time jobs in firms. When decomposing wages in the All Firms case, instead of assigning all workers and to the employment area where a firm has the greatest amount of workers, firms that operate in two different employment areas are treated as two separate firms.

$$
\begin{aligned}
V(w_{i,j(i),a(i)}) &= V^{BA} + V^{WA}, \\
&= V^{BA} + V^{WABF} + V^{WAWF},
\end{aligned}
\tag{2}
$$

where $w_{i,j(i),a(i)}$ is the log hourly wage of worker i employed in firm $j(i)$ and operating in employment area $a(i)$, V^{BA} measures the variation in wages across employment areas, and V^{WA} measures the variation in wages within employment areas. Furthermore, V^{WA} can be decomposed into the sum of V^{WABF} and V^{WAWF}, which measure the variation in wages within areas that is across and within firms, respectively.[14]

[14] V^{WABF} and V^{WAWF} are a further decomposition of the variation within employment areas, V^{WA}. That is, the following identity holds: $V^{WA} = V^{WABF} + V^{WAWF}$. Further, to be precise, let $E \log w$ denote the average log

Table 3 reports results for the year 2004. Most of the results are based on the baseline sample of manufacturing firms, however, to show the findings from this study are robust, Table 3 also reports results from the population of manufacturing firms and the sample of single establishment firms.

The top panel reports decomposition results using all workers and log hourly net wages. Across all manufacturing firms, approximately 88% of the variation in log hourly net wages occurs within employment areas. From this variation, 69% takes place within as opposed to across firms, implying the variation in wages that is within firms accounts for roughly 60% of the overall dispersion in wages. In the sample of firms used in this study, in part because small firms are removed from the sample, the within-firm variation plays a greater role. Approximately 96% of the variation occurs within employment areas and nearly 71% of this is within as opposed to across firms. Overall the within-firm variation in wages accounts for nearly 68% of the overall dispersion in wages. Restricting the sample further to single establishment firms does not change results. In this case, roughly 68% of the overall dispersion in wages is within firms.

The next two panels report decomposition results for different groups of workers. Naturally, not all jobs are the same and part of the variation in wages may be due to differences in the wages of part-time and full-time workers. To show the findings are robust to this concern, the second panel conducts the same decomposition exercise using only full-time workers. Across all manufacturing firms, approximately 87% of the variation in log hourly net wages is within employment areas, and roughly 69% of this variation is within firms. The within-firm variation accounts for roughly 60% of the overall dispersion in wages. In the baseline sample and the sample with single establishment firms, results are similar. The majority of the variation in wages is within employment areas, approximately 71% of the variation within areas is within firms, and the within-firm variation in wages accounts for nearly 68% of the overall wage dispersion in manufacturing.

Another concern is that part of the variation is from differences in the wages of male and female workers (see for example, Blau and Kahn (1996), Christofides et al. (2013), and Blau and

hourly wage, and $E\log w_a$ denote the average wage in employment area a. Then the across and within employment areas terms are equal to: $V^{BA} = (1/N)\sum_a \sum_{j\in a}\sum_{i\in j,a}(E\log w_a - E\log w)^2 = (1/N)\sum_a N_a(E\log w_a - E\log w)^2$, and $V^{WA} = (1/N)\sum_a \sum_{j\in a}\sum_{i\in j,a}(\log w_{i,j(i),a(i)} - E\log w_a)^2$, where N is the number of workers in the economy and N_a denotes the number of jobs in area a. Furthermore, let $E\log w_{j,a}$ denote the average log hourly wage in firm j in area a. Then V^{WABF} and V^{WAWF} are equal to: $V^{WABF} = (1/N)\sum_a \sum_{j\in a}\sum_{i\in j,a}(E\log w_{j,a} - E\log w_a)^2 = V^{WABF} = (1/N)\sum_a \sum_{j\in a} N_j(E\log w_{j,a} - E\log w_a)^2$ and $V^{WAWF} = (1/N)\sum_a \sum_{j\in a}\sum_{i\in j,a}(\log w_{i,j(i),a(i)} - E\log w_{j,a})^2 = (1/N)\sum_a \sum_{j\in a} N_{j,a} V_j(\log w_{i,j(i),a(i)})$, where $N_{j,a}$ denotes the number of jobs in firm j in area a, and $V_j(\log w_{i,j(i),a(i)})$ is the variance of wages in firm j.

Kahn (2017)). To show the findings are robust to gender differentials, the third panel performs the same decomposition on full-time male workers. The conclusions remain the same. In all three samples, most of the variation in log hourly net wages is within employment areas, and within firms. For instance, in the baseline sample, approximately 96% of the variation in log hourly net wages is within areas, nearly 70% of this is within firms, and the variation within firms accounts for approximately 67% of the overall dispersion in log hourly net wages.

The bottom panel of Table 3 further illustrates the findings are robust to different measures of wages and income. In all cases, most of the the variation is within areas, and within firms. For instance, instead of using hourly net wages consider the findings for net earnings. The bottom panel of Table 3 indicates that roughly 80% of the variation in log net earnings is within areas, nearly 83% of the variation within employment areas is within firms, and the within-firm variation accounts for approximately 67% of the overall dispersion in log net earnings.[15]

Naturally, other decompositions are also possible, such as a decomposition, across and within, industries and areas. Using different decompositions will not change this subsection's findings because the within-firm variation will remain the same. Furthermore, since most of the variation in wages is within firms, and the majority of firms operate in a finite number of areas, the majority of the dispersion in wages will still take place within employment areas. The general findings from the analysis will therefore be unchanged.

To summarize, two main conclusions emerge from the variance decomposition analysis. First, the majority of the variation in wages is within employment areas, and second, within employment areas, the majority is within firms. This implies that understanding the structure of wages within firms would improve our understanding of spatial wage disparities, and more generally wage disparities in the economy.[16] The following subsection is devoted to understanding the disparity of wages within firms. More precisely, the following subsection examines how the amount of wage dispersion in firms varies with the density of areas. In addition, since restricting the sample to single establishment firms does not change findings, the analysis mainly focuses on the baseline sample composed of independent manufacturing firms with at least 4 employees and operating in a single employment area.

[15] Since the residuals are obtained from regressions with area fixed effects, the variation between areas is equal to zero.

[16] These results are also consistent with other studies (see for example Davis and Haltiwanger (1991), Akerman et al. (2013), Friedrich (2015), Barth et al. (2016), Helpman et al. (2017) and Song et al. (2017)). For instance, for the years 1992 and 2007, Barth et al. (2016) perform a similar decomposition using data from the US Census Bureau and find that nearly 54.2% and 51.0% of the variation in workers' wages occurs within establishments.

Table 4: Variance within Firms and Density

Dependent Variable: Variance of Log Hourly Net Wages (in logs)	(1)	(2)	(3)	(4)	(5)	(6)
log density	0.113	0.108	0.104	0.071	0.064	0.042
	$(0.008)^a$	$(0.012)^a$	$(0.007)^a$	$(0.016)^a$	$(0.013)^a$	$(0.017)^b$
Method	OLS	OLS	2SLS	2SLS	OLS	2SLS
First-Stage Statistics						
KP Wald F-Statistic	-	-	391.51	24.54	-	13.98
Over-Id Test (p-value)	-	-	0.295	0.152	-	0.300
R-squared	0.216	0.220	-	-	0.223	-
Sample Size	66,975	66,975	62,784	62,784	66,975	62,784
Market Potential	N	Y	N	Y	Y	Y
Employment Diversity	N	Y	N	Y	Y	Y
Endowment Controls	N	Y	N	Y	Y	Y
Demographic Controls	N	N	N	N	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y

Notes: a,b,c: significant at the 1%, 5% and 10% level. Standard errors clustered at the employment area level. Dependent variable is the variance of log hourly net wages (in logs). Industry fixed effects at the four-digit NAF Rev 1 level. Demographic controls are the following: the share of foreign-born individuals residing in an area, the fraction of the local population over the age of 25 with a university degree, as well as the share unemployed individuals in a local area. In Column (2) instruments are the following: the log of density from 1831, 1851 and 1881. In Column (3) instruments are the following: the log of density from 1831, 1851 and 1881, log of market potential in 1881, and the economic composition of areas in 1968. In Column (6) instruments are the following: the log of density from 1831, 1851 and 1881, log of market potential in 1881, and the economic composition of areas in 1968, the share of foreign-born individuals residing in an area in 1968, and the fraction of the local population over the age of 25 with a university degree in 1968.

5.2 Within-Firm Wage Disparities and Density

This subsection examines how wage disparities within firms varies with the density of areas. To the best of my knowledge, this relationship has not been examined in the urban literature. It is of interest, however, because the majority of the variation in wages is within firms, and because the relationship in this section connects, at the local level, the outcomes of firms with the economic outcomes of workers.

To examine how wage disparities within firms varies with the density of areas, for firm j operating in employment area $a(j)$, I estimate the following equation:

$$\log I_{j,a(j)} = \beta_0 + \beta_1 D_{a(j)} + \beta_2 E_{a(j)} + s_j + \epsilon_{j,a(j)}, \tag{3}$$

where $I_{j,a(j)}$ measures the wage dispersion within firm j, s_j are industry fixed effects, and the remaining variables have been described above. The variable of interest in equation (3) is β_1, the elasticity of within-firm wage dispersion with respect to the density of employment areas. Naturally, given the evidence presented above, we would expect β_1 to be positive.

Table 4 contains the main results. The dependent variable in Table 4 is the variance of log hourly net wages, and each specification contains industry fixed effects and is estimated with standard errors clustered at the employment area level. Columns 1-2 report OLS results. Column 1 only controls for the density of employment areas. The point estimate is positive and significant, and the finding indicates there are greater wage disparities in firms located in denser areas. A 1% increase in the density of an area is associated with a 11.3% increase in the wage dispersion within firms.

Although it is a basic, the specification in Column 1 contains the general finding from this section's analysis. There are greater wage disparities in firms located in denser areas. The remaining objective of this section is to examine the robustness of this result. Following the discussion in Section 4, Column 2 introduces measures of the market potential, the economic composition as well as the endowments of employment areas. The results continue to indicate there are greater wage disparities in firms operating in denser areas. A 1% increase in density is associated with a 10.8% increase in variance of log hourly net wages within firms.

To show the findings are robust to endogenous variables, Columns 3-4 instrument for density, the market potential, and the economic composition of employment areas and report 2SLS results. Column 3 returns to the specification in Column 1 and instruments for density using historical values from 1831, 1851 and 1881. Even though the estimated density elasticity is statistically smaller than its OLS counterpart, the conclusions stay the same. A 1% increase in the density of an area results in a 10.4% increase in the variance of log hourly wages within firms. Column 4 comes back to the specification in Column 2 and instruments for density, market potential, and the economic composition of employment areas using lagged values. In this case, the point estimate on density is positive and significant, yet it is statistically smaller than its OLS counterpart. A 1% increase in the density of an area increases the variance of log hourly wages in firms by 7.1%. It is also important to note that the middle panel of Table 4 reports results from statistical tests assessing the validity of the instruments. The findings indicate that the instruments in Columns 3-4 are valid. According to the the Wald F-statistic from Kleibergen and Paap (2006) they are not weak, and they also pass the Sargan-Hansen over-identification test.

Moreover, to show the findings are robust to differences in the composition of employment areas, Column 5-6 also control for the demographic characteristics of areas. Column 5 goes back to the specification in Column 3 and also controls for the share of foreign-born individuals, the share of individuals over the age of 25 with a university degree, and the share of unemployed individuals residing in an area, variables that are commonly thought to have an effect on local labor markets and local inequality. Column 5 reports that density continues to have an effect on the dispersion of wages in firms. The estimated density elasticity is positive and significant, and a 1% increase in density is associated with 6.4% increase in the wage dispersion in firms. Column 6 reports 2SLS results and instruments for the density, the market potential, the economic composition and the demographic characteristics of employment areas using lagged values. Column 6, however, does not instrument for the share of unemployed individuals residing in an area, because the hypothesis that it is exogenous cannot be rejected at acceptable levels of significance. The conclusions remain the same. In Column 6, the point estimate on density is positive and significant, and it is statistically identical to its OLS counterpart. A 1% increase in the density of an area results in a 4.2% increase in the variance of log hourly wages within firms.

Thus far, the evidence indicates there are greater wage disparities in firms operating in denser areas. Table 5 returns to the specification in Column 5 of Table 4 and assesses whether these findings are robust to measures of dispersion based on different sources of incomes. Columns 1 and 2 measure the dispersion of wages in firms using different groups of workers. In Column 1 the dependent variable is the variance of log hourly net wages of full-time workers. The estimated density elasticity is positive and significant. In Column 2 the dependent variable is the variance of log hourly net wages of full-time male workers. The estimated magnitude on density is comparable to Column 1, and it indicates that a 1% increase in the density of an area is associated with a 7.8% in the wage dispersion of full-time male workers, within the same firm.

The remaining columns in Table 5 use different measures of incomes. In Column 3 the dependent variable is the variance of log hourly gross wages. The point estimate on density is similar to Column 5 of Table 4. In Column 4 the dependent variable is the variance of log net earnings. The evidence indicates there is greater earnings dispersion in firms operating in denser areas. In Column 5 the dependent variable is the variance of log gross earnings. The conclusion stays the same. The estimated coefficient on density is positive and significant, and a 1% increase in density is associated with a 2.2% increase in the dispersion of earnings within firms.

Furthermore, workers have different characteristics, and part of the variation in wages may simply be due to different types of workers being employed in different areas and in different firms (see Combes and Gobillon (2015) and Chade et al. (2017) and the references therein). To show the findings are robust to this concern, Columns 6-7 report results using measures of wage disparities constructed from residual wages. The analysis yields the same conclusions. In Column 6 the residuals are from a wage regression that controls for workers' observable characteristics.

Table 5: Robustness I - Variance within Firms and Density

Dependent Variable: Variance of Wages (in logs)	Full-Time Workers (1)	Full-Time Male Workers (2)	Hourly Gross Wages (3)	Net Earnings (4)	Gross Earnings (5)	Residual Wages I (6)	Residual Wages II (7)
log density	0.084	0.078	0.068	0.024	0.022	0.049	0.040
	(0.015)[a]	(0.016)[a]	(0.013)[a]	(0.010)[b]	(0.010)[b]	(0.010)[a]	(0.020)[b]
Method	OLS	OLS	OLS	OLS	OLS	OLS	OLS
R-squared	0.181	0.181	0.228	0.048	0.049	0.206	0.029
Sample Size	63,401	57,189	66,973	66,970	66,974	66,983	58,991
Market Potential	Y	Y	Y	Y	Y	Y	Y
Employment Diversity	Y	Y	Y	Y	Y	Y	Y
Endowment Controls	Y	Y	Y	Y	Y	Y	Y
Demographic Controls	Y	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y	Y

Notes: a,b,c: significant at the 1%, 5% and 10% level. Standard errors clustered at the employment area level. Industry fixed effects at the four-digit NAF Rev 1 level. Demographic controls are the following: the share of foreign-born individuals residing in an area, the fraction of the local population over the age of 25 with a university degree, as well as the share unemployed individuals in a local area. In Column (1) the dependent variable is the the variance of log hourly net wages of full-time workers (in logs). In Column (2) the dependent variable is the variance of log hourly net wages of full-time male workers (in logs). In the remaining columns the dependent variable is the variance of different measures of incomes (in logs). These are listed on the top of each column.

The estimated coefficient on density is positive and significant. A 1% increase in density is associated with a 4.9% increase in the residual wage dispersion within firms. In Column 7, the residuals are from a wage regression that accounts for workers' observable and unobservable attributes. Even in this case, the evidence indicates there is greater wage dispersion in firms operating in denser areas. A 1% increase in the density of an area is associated with a 4.0% increase in the residual wage dispersion in firms.

In the Appendix, Table A1 reports another set of robustness results. Each column returns to the specification in Column 5 of Table 4 and examines the relationship between the density of employment areas and the wage dispersion in firms, using different samples of firms. Column 1 considers all manufacturing firms operating in a single employment area, Column 2 retains firm with at least 90% of their workers in a single area, Column 3 assigns firms with at least 4 employees to the employment area where the majority of their workforce is located, Column 4 retains all manufacturing firms with at least 4 employees operating in a single area, and Column 5 retains single establishment firms. In all cases, the relationship between density and the variance of log hourly net wages in firms remains positive and significant. For instance, Column 1 reports a 1% increase in density is associated with a 11.5% increase in the wage dispersion in firms.

To examine whether the findings are robust to differences in the characteristics of firms, Table A2 in the Appendix reports results from specifications that progressively control for the attributes of firms. Column 1 returns to the specification in Column 5 of Table 4 and also controls for the size of firms, measured using hours. The estimated density elasticity is positive and significant, and a 1% increase in density is associated with a 4.8% increase in the wage dispersion in firms. The remaining columns progressively include additional controls for the characteristics of firms. Column 2 controls for the number of additional occupations in firms, Column 3 includes the export status of firms, and Column 4 further controls for the amount of capital in firms. In all cases, density continues to have an effect on the structure of wages in firms. Along with the preceding variables Column 5 also controls for the legal status of firms. The estimate on density remains positive and significant, and a 1% increase in density is associated with a 4.5% increase in the wage dispersion in firms.

Also in the Appendix, Table A3 reports results using other measures of wage disparities in firms. Columns 1-4 examine whether density increases the gap between workers located in the 95th and in the 5th percentile of the distribution of wages and earnings in firms. The specification is similar to Column 5 of Table 4, however the dependent variables in Table A3 are not transformed using logs. In Column 1 the dependent variable is the 95-5 log hourly net wage gap, in Column 2 it is the 95-5 log hourly gross wage gap, in Column 3 it is the 95-5 log net earnings gap, and in Column 4 the dependent variable is the 95-5 log gross earnings gap. In all cases, the findings indicate there are greater disparities in firms operating in denser employment areas. For instance, Column 1 indicates that a 1% increase in density of an area is associated with a 2.0% increase in the 95-5 log hourly net wage gap in firms. Columns 5 and 6 further decompose the 95-5 log hourly net wage gap into the 95-50 and the 50-5 gaps. In both cases, the point estimates are positive and significant. Columns 5 and 6 indicate that a 1% increase in density of an area is associated with a 1.3% increase in the 95-50 log hourly net wage gap in firms, and a 0.7% increase in the 50-5 log hourly net wage gap in firms.

To summarize, the evidence indicates there are greater wage disparities in firms operating in denser areas. These findings from this subsection are not only statistically significant but they also have economic meaning. To make sense of the magnitudes involved, consider the results in Table 4, and the hypothetical experiment of increasing the average density of employment areas in the first quartile of the density distribution to the fourth. The average density of employment areas in the first quartile is 0.315, while in the fourth quartile it is equal to 29.709. Furthermore, the magnitudes in Table 4 suggest that the variance of log hourly net wages in firms will also increase by 21.6%$(\approx 94.31^{0.043} - 1)$ to 67.2%$(\approx 94.31^{0.113} - 1)$. The remaining objective of this paper, is to investigate the extent the increasing wage dispersion observed in firms operating in denser areas results from the effect density has on the organization of firms.

6 Organization and Wage Disparities

I now turn to the organization of firms. The analysis in this section advances in stages. First, I show that in denser areas firms organize with a greater number of layers. Second, I examine the structure of wages within firms, and show there is greater wage dispersion in firms that organize with a greater number of layers. In view of these findings, in the last section I examine the extent the spatial differences in the way firms organize production accounts for the finding in the previous section, that there is greater wage dispersion in firms that operate in denser areas.

6.1 The Organization of Firms Across Areas

This section shows manufacturing firms in denser employment areas organize with a greater number of layers. The analysis in this section contains two parts. Following Spanos (2016) and Spanos (2017), I first show there is a stochastic ordering of the distribution of organizations across areas. Then I turn to regression analysis to examine how the organization of firms varies with the density of employment areas, while addressing the identification issues described above.

Table 6 presents evidence that firms in denser areas organize with a greater number of layers. More precisely, Table 6 groups employment areas by their density and compares the distributions of organizations with the Mann-Whitney test, which is a non-parametric stochastic dominance test. The null hypothesis of the test is both distributions are identical, while the alternative is that in one group of areas firms have a greater number of layers. In Table 6, Column 1 reports the p-value of the test and Column 2 reports the probability that a randomly selected firm from an employment area with above-median density has a greater number of layers than a randomly selected firm from an area with below-median density.

The first row in Table 6 groups all industries together, while the remaining rows compare the distribution of organizations in industries with at least 200 observations. In every case where the null hypothesis is rejected, the test indicates there is a ranking of distributions, with the distribution of organizations in denser areas having a greater share of firms organizing with a greater number of layers. To put this differently, the test indicates the distribution of organizations in denser areas first-order stochastically dominates the distribution in less dense areas. For

Table 6: Mann-Whitney Distribution Tests

	Null Hypothesis: Distributions are Equal	Probability Above-Median > Below Median
ALL Industries	0.000	0.540
Food Products & Beverages	0.956	0.500
Textiles	0.032	0.536
Apparel, Dressing & Dyeing of Fur	0.870	0.503
Leather Products	0.756	0.508
Wood & Wood Products	0.000	0.542
Paper & Paper Products	0.804	0.507
Publishing & Printing	0.000	0.548
Chemicals & Chemical Products	0.016	0.554
Rubber & Plastics Products	0.020	0.533
Non-Metallic Mineral Products	0.000	0.567
Basic Metals	0.436	0.474
Fabricated Metal Products	0.000	0.528
Machinery & Equipment	0.000	0.577
Electrical Machinery & Apparatus	0.062	0.537
Radio, Television and Communication Equipment	0.071	0.548
Medical & Optical Instruments, Watches & Clocks	0.000	0.555
Motor Vehicles and Trailers	0.128	0.533
Transport Equipment	0.179	0.458
Furniture Products	0.079	0.519
Recycling	0.000	0.579

Notes: Results of Mann-Whitney stochastic dominance test. The null hypothesis is that both distributions are equal. Column 1 reports the p-value of the test. Column 2 reports the probability that random draw of a firm from an area with below-median density has greater number of layers than a random draw of firm from an area with above-median density. Industries are based on the 2-digit NAF Revision 1 classification.

instance, in the Machinery & Equipment industry, the Mann-Whitney test indicates that a randomly selected firm from an employment area with above-median density is 57.7% more likely to have a greater number of layers than a random firm from an area with below-median density.

To summarize, the way firms organize production is not random across areas. The results from the Mann-Whitney test indicate the distribution of organizations in denser areas first-order stochastically dominates the distribution in less dense areas. One implication of this result is that firms in denser employment areas on average have a greater number of layers.

The Mann-Whitney test, however, has limitations. As discussed in Spanos (2017), the main assumption of the Mann-Whitney test is that there does not exist a relationship between firms within each area or across the areas themselves. Following the discussion in Section 4, this assumption is unlikely to hold. As a result, I now turn to regression analysis to examine whether the density of employment areas has an effect on the number of layers in firms. More precisely, for firm j operating in employment area $a(j)$, I estimate the following equation:

$$ORG_{j,a(j)} = \gamma_0 + \gamma_1 D_{a(j)} + \gamma_2 E_{a(j)} + s_j + \epsilon_{j,a(j)}, \quad (4)$$

where $D_{a(j)}$ is the natural log of the local density of an area a, $E_{a(j)}$ controls for the additional characteristics of employment areas, and s_j are industry fixed effects. The dependent variable $ORG_{j,a(j)}$ measures the total number of layers in firm j. The main parameter of interest is γ_1 which is expected to be positive.

Table 7 reports the main results from the baseline sample. All specifications are estimated with industry fixed effects and standard errors clustered at the employment area level. Column 1, which only controls for density, reports results from the simplest specification in the table. Although it is short, the coefficients are indicative of this section's general finding. The point estimate on density is positive and significant, and indicates that firms in denser areas organize with a greater number of layers. More precisely, Column 1 indicates that a 100% increase in the density of an area is approximately associated with an additional 0.033 ($\approx -\log(2) * 0.047$) layers in firms.

To see the robustness of this basic finding, consider the specification in Column 2, which controls for the market potential, the economic composition and the endowments of employment areas. The coefficient on density remains positive and significant, however, its magnitude is lower than in Column 1. This is not surprising, considering that the other characteristics of areas also have an effect on the outcomes of firms. For instance, a well established result from the urban literature is that denser markets have greater access, and that the market potential of areas also has an effect on the outcomes of firms (see Combes and Gobillon (2015) and references therein). Nonetheless, despite the extra controls, density continues to determine the organization of firms. Column 2 indicates that a 100% increase in the density of an area is associated with an extra 0.030 layers in firms.

To deal with potentially endogenous variables, Columns 3-4 further instrument for the density, the market potential and the economic composition of employment areas, and report 2SLS results. Column 3 returns to the specification in Column 1 and instruments for density using historical values from 1831, 1851 and 1881. The coefficient on density is positive and significant, and it's magnitude is statistically lower than its OLS counterpart. The results, however, continue to indicate that firms in denser areas organize with more layers. A 100% increase in the density of an area results in an additional 0.029 layers in firms. In parallel, Column 4 returns to the specification in Column 2, and instruments for density, the market potential and the economic composition

Table 7: Organization and Density

Dependent Variable: Number of Layers	(1)	(2)	(3)	(4)	(5)	(6)
log density	0.047	0.044	0.042	0.024	0.037	0.021
	(0.005)[a]	(0.006)[a]	(0.005)[a]	(0.008)[a]	(0.007)[a]	(0.010)[b]
Method	OLS	OLS	2SLS	2SLS	OLS	2SLS
First-Stage Statistics						
KP Wald F-Statistic	-	-	391.64	24.54	-	13.98
Over-Id Test (p-value)	-	-	0.202	0.256	-	0.525
R-squared	0.322	0.323	-	-	0.324	-
Sample Size	66,983	66,983	62,792	62,792	66,983	62,792
Market Potential	N	Y	N	Y	Y	Y
Employment Diversity	N	Y	N	Y	Y	Y
Endowment Controls	N	Y	N	Y	Y	Y
Demographic Controls	N	N	N	N	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y

Notes: a,b,c: significant at the 1%, 5% and 10% level. Standard errors clustered at the employment area level. Dependent variable is the number of layers in firms. Industry fixed effects at the four-digit NAF Rev 1 level. Demographic controls are the following: the share of foreign-born individuals residing in an area, the fraction of the local population over the age of 25 with a university degree, as well as the share unemployed individuals in a local area. In Column (2) instruments are the following: the log of density from 1831, 1851 and 1881. In Column (3) instruments are the following: the log of density from 1831, 1851 and 1881, log of market potential in 1881, and the economic composition of areas in 1968. In Column (6) instruments are the following: the log of density from 1831, 1851 and 1881, log of market potential in 1881, and the economic composition of areas in 1968, the share of foreign-born individuals residing in an area in 1968, and the fraction of the local population over the age of 25 with a university degree in 1968.

of employment areas using lagged values. In this case, the point estimates are positive and significant, however the magnitude on density is statistically lower from the corresponding OLS estimates. Nonetheless, the findings remain the same and density continues to have an effect on the organization of firms. A 100% increase in the density of an area results in an additional 0.017 layers in firms. Also note that the middle panel of Table 7 indicates that in Columns 3-4 the instruments are again valid, in the sense the Wald F-statistic from Kleibergen and Paap (2006) indicates they are not weak, and they also pass the Sargan-Hansen over-identification test.

Along with the market potential, the economic composition and the endowments of areas, Columns 5-6 further control for the demographic characteristics of employment areas. Column 5 returns to the specification in Column 3 and controls for the share of foreign-born individuals, the share of individuals over the age of 25 with a university degree, and the share of unemployed individuals residing in an area. Unsurprisingly, in this case the coefficient on density is lower than in Columns 1 and 2. Column 6 further reports 2SLS results and instruments for density, the market potential, the economic composition and the demographic composition of areas, using lagged values. As in the previous section, Column 6 does not instrument for the share of unemployed individuals in the local population, because the hypothesis that it is exogenous cannot be rejected at acceptable levels of significance. In this case, the point estimate on density is statistically identical to its OLS counterpart, and the conclusions stay the same. A 100% increase in the density of an area results in an extra 0.015 layers in firms.

In the Appendix, Table A4 reports a series of robustness results. Columns 1-5 return to the specification in Column 5 of Table 7 and consider different samples of firms. Column 1 considers all manufacturing firms operating in a single employment area, Column 2 assigns firms with at least 4 employees to the employment area where they have the majority of workers, Column 3 retains firms with at least 90% of their workers in a single area, Column 4 contains all manufacturing firms with at least 4 employees operating in a single area, and Column 5 restricts the sample to single establishment firms. In all cases, the relationship between density and the number of layers in firms remains positive and significant. For instance, Column 1 reports a 100% increase in the density of an area is roughly associated with an additional 0.040 ($\approx \log(2) * 0.058$) layers in firms.

Furthermore, to assess whether the findings are robust to the characteristics of firms, Table A5 in the Appendix reports results with firm level controls. Column 1 returns to the specification in Column 5 of Table 7 and only controls for the size of firms, measured using hours. The point estimates remain positive and significant, and a 100% increase in the density of an area is associated with an extra 0.011 layers in firms. Columns 2-5 progressively control for additional characteristics of firms. Column 2 also controls for the number of additional occupations in firms. The findings are similar and density continues to have an effect on the organization of firms. Moving forward, Column 3 further controls for the export status of firms. Again, the conclusions remain the same, and a 100% increase in the density of an area is approximately associated with an extra 0.010 layers in firms. Column 4 also includes the amount of capital in firms, and Column 5 further controls for the legal status of firms. In both cases, the estimates on density remain positive and significant, and indicate that firms in denser areas have more layers.

To summarize, the main takeaway from this section is firms in denser employment areas organize with a greater number of layers. The coefficients on density are in the range of 0.014 to 0.058, implying that increasing the average density of employment areas in the first quartile of the density distribution to the fourth, results in an additional 0.064 to 0.264 layers in firms. Together with the facts presented above, this implies one possible reason there are greater wage disparities in firms operating in denser areas, is because firms in denser areas organize with a greater number of layers. The next subsections deal with this question.

Table 8: Variance within Firms and Organization

	Hourly Net Wages (1)	Full-Time Workers (2)	Full-Time Male Workers (3)	Hourly Gross Wages (4)	Net Earnings (5)	Gross Earnings (6)	Residual Wages I (7)	Residual Wages II (8)
organization	0.747	0.762	0.821	0.754	0.138	0.136	0.620	0.489
	$(0.011)^a$	$(0.011)^a$	$(0.011)^a$	$(0.011)^a$	$(0.006)^a$	$(0.007)^a$	$(0.006)^a$	$(0.011)^a$
Method	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
R-squared	0.429	0.332	0.310	0.431	0.064	0.064	0.396	0.082
Sample Size	66,975	63,401	57,189	66,973	66,970	66,974	66,983	58,991
Area FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y	Y	Y

Notes: a,b,c: significant at the 1%, 5% and 10% level. Standard errors clustered at the employment area level. The dependent variable is the variance of measures of incomes (in logs). Industry fixed effects at the four-digit NAF Rev 1 level. In Column (2) the dependent variable is the the variance of log hourly net wages of full-time workers (in logs). In Column (3) the dependent variable is the variance of log hourly net wages of full-time male workers (in logs). In the remaining columns the dependent variable is the variance of different measures of incomes (in logs). These are listed on the top of each column.

6.2 Within-Firm Wage Disparities and the Organization of Firms

To make the argument that organization is important for understanding the disparity of wages in firms, I estimate the following equation:

$$\log I_{j,a(j)} = \delta_0 + \delta_1 ORG_{j,a(j)} + a_j + s_j + \epsilon_{j,a(j)}, \quad (5)$$

where $I_{j,a(j)}$ measures the wage dispersion in firm j, $ORG_{j,a(j)}$ measures the number of layers in firm j operating in employment area $a(j)$, a_j are employment area fixed effects and s_j are industry fixed effects.

Table 8 reports OLS results from the baseline sample, with standard errors clustered at the employment area level and with measures of dispersion based on different sources of income. In Column 1 the dependent variable is my baseline measure of wage dispersion, the variance of log hourly net wages. The point estimate on organization is positive and significant, and indicates there are greater wage disparities in firms with a greater number of layers. The magnitude of the estimated coefficient on organization is also large. Column 1 indicates that an extra layer is approximately associated with a 111% ($\approx$ $(\exp^{0.747} - 1) * 100$) increase in the variance of log hourly net wages in firms, which corresponds to more than a doubling of the wage dispersion in firms.

To show that this finding is robust, the remaining columns of Table 8 reports results using measures of wage dispersion that are based on different groups of workers and different sources of income. Columns 2 and 3 measure the wage dispersion between full-time workers and full-time male workers employed in the same firm. The findings again indicate there are greater wage disparities in firms operating with a greater number of layers. For instance, Column 3 reports than an additional layer is associated with a 127% increase in the wage dispersion of full-time male workers employed in the same firms. In Column 4 the dependent variable is based on hourly gross wages. The estimated coefficient on organization is positive and significant, and the conclusions stay the same. An extra layer is associated with a 113% increase in the wage dispersion within firms.

Instead of hourly wages, Columns 5 and 6 report results using measures of earnings. In Column 5 the dependent variable is the variance of log net earnings, and in Column 6 the dependent variable is based on gross earning. The magnitudes are almost identical and they continue to indicate there are greater wage disparities in firms with a greater number of layers. For instance, in Column 6, an extra layer is associated with a 14.6% increase in the variance of log gross earnings in firms.

To examine whether the findings are robust to differences in the composition of workers across areas and firms, Columns 7 and 8 report results using measures of wage disparities constructed from residual wages. In Column 7 residual wages are obtained from a Mincerian wage regression that controls for the observable characteristics of workers reported in the DADS. The point estimate on organization remains positive and significant, and an extra layer is roughly associated with a 85.9% increase in the residual wage dispersion in firms. In Column 8 residual wages are recovered from a wage regression that also accounts for individuals' unobservable characteristics. The findings continue to indicate there are greater wage disparities in firms operating with a greater number of layers. In Column 8, an additional layer is approximately associated with a 63.1% increase in variance of residual wages in firms. Accounting for differences in the composition of workers, therefore, yields similar conclusions.

In the Appendix, Table A6 which has the same structure as Table 8, goes even further and reports results from the most conservative specification with respect to the organization of firms. More precisely, instead of having separate industry and area fixed effects as in equation (5), Table A6 reports results from specifications with industry-area interaction effects. It is important to note that in this specification, all of the variation across industries and employment areas, are absorbed by these effects. Nonetheless, in all cases the magnitude of the estimated coefficients on organization are similar to the point estimates in Table 8. For instance, Column 1 reports that an additional layer is approximately associated with a 110% increase in variance of log hourly net wages in firms. The conclusion, therefore, remain the same and organization continues to be related to the amount of wage dispersion in firms.

Table A7, also in the Appendix, reports results from another series of robustness checks. Columns 1-4 return to the specification in Column 1 of Table 8 and examine how the wage dispersion within firms varies with the number of layers in firms, across different samples of firms. Column 1 considers all manufacturing firms operating in a single area, Column 2 retains firms with at least 90% of their workers in a single area, Column 3 assigns firms with at least 4 employees to the employment area with the majority of their workers, Column 4 contains all manufacturing firms with at least 4 employees operating in a single area, and Column 5 only retains single establishment firms. In all cases, the relationship between organization and the wage dispersion in firms remains positive and significant. For instance, Column 1 reports an additional layer is associated with a 158% ($\approx (\exp^{0.949} - 1) * 100$) increase the variance of log hourly net wages in firms.

Another concern with the analysis, is there are other firm characteristics that may also have an effect on the structure of wages within firms. For instance, the degree of wage dispersion in firms may vary with the capital intensity in production (Leonardi (2007)). Additionally, a group of studies have documented that selling to foreign markets has an effect on the structure of wages in firms (see for example Caliendo and Rossi-Hansberg (2012), Akerman et al. (2013), Friedrich (2015), and Helpman et al. (2017)). To assess whether the findings in Table 8 are robust to these concerns, Table A8 in the Appendix controls for the characteristics of firms. Column 1 returns to the specification in Column 1 of Table 8 and controls for the size of firms. The point estimate on organization is again positive and significant. An extra layer is associated with a 109% increase in variance of log hourly net wages in firms. The remaining columns progressively introduce additional controls of the characteristics of firms. Column 2 adds as a control the number of additional occupations in firms, Column 3 also controls for the export status of firms, Column 4 additionally controls for the level of capital in firms, and Column 5 also includes as a control the legal status of firms. In all cases, the findings lead to the same conclusion. There are greater wage disparities in firms operating with a greater number of layers. For instance, Column 5 reports that an extra layer is approximately associated with a 97.2% ($\approx (\exp^{0.672} - 1) * 100$) increase in variance of log hourly net wages in firms.

Table A9 further shows the findings are robust to different measures of the amount of disparities in firms. Similar to Table 8 each column in Table A9 controls for the industry and area of firms, however the dependent variables are not log transformed. Columns 1-4 examine whether organization is associated with a greater differential between workers in the 95th and 5th percentile of the distribution of wages and earnings in firms. In Column 1, the 95-5 wage gap is measured using log hourly net wages, in Column 2 it is measured using log hourly gross wages, in Column 3 the 95-5 earnings gap is measured using log net earnings, and in Column 4 it is measured using log gross earnings. In each case, the findings indicate there are greater disparities in firms operating with a greater number of layers. For instance, Column 1 reports that an additional layer is approximately associated with a 35.3% increase in the 95-5 log hourly net wage gap in firms. Columns 5 and 6 further decompose the 95-5 log hourly net wage gap into the 95-50 and the 50-5 wage differential in firms. In both cases, the point estimates are positive and significant. Not surprisingly, an extra layer is associated with greater disparities in the upper half of the distribution of wages in firms. Column 5 reports that an additional layer is approximately associated with a 27.4% increase in the 95-50 log hourly net wage gap, and Column 6 reports that it is associated with a 6.1% increase in the 50-5 wage gap in firms. This is consistent with the knowledge-based management hierarchy models of Garicano (2000), which argue that additional layers benefit the most knowledgeable workers situated in the higher layers of firms (see also Garicano and Rossi-Hansberg (2004), Garicano and Rossi-Hansberg (2006) and Antras et al. (2006)).

To summarize, the evidence indicates there are greater wage disparities in firms with a greater number of layers. The point estimates reported in this section are also economically relevant. To get a better sense of their economic significance, consider the distribution of the variance of log hourly net wages within firms. In the first quartile firms on average organize with 1.248 layers, while in the fourth quartile firms on average have 2.921 layers in their organization. Additionally, the average variance of log hourly net wages in firms located in the first and fourth quartiles are 0.011 and 0.245, respectively. Using the point estimates from this subsection, a back of the envelope calculation implies that differences in the way firms organize production accounts for approximately 9.9% ($\approx$ $(\exp^{(2.921-1.248)*0.679} - 1) * 0.011/(0.245 - 0.011)$) to 18.3% ($\approx$ $(\exp^{(2.921-1.248)*0.949} - 1) * 0.011/(0.245 - 0.011)$) of the average increase in the wage dispersion within firms.[17]

Furthermore, the mechanism presented in this study has not been explored in the urban litera-

[17] Performing the same thought on experiment on firms in the third and fourth quartiles of the distribution, yields estimates in the range of 18.1% to 26.6%.

ture analyzing the nature and sources of spatial wage disparities. The next subsection documents that it also accounts for a meaningful share of the relationship between the density of employment areas and the wage disparities in firms.

6.3 Within-Firm Wage Disparities & Density: Direct and Indirect Effects

We now have all the pieces in place to assess the extent organization contributes to the greater wage disparities observed in firms operating in denser areas. Consider the following equation:

$$\log I_{j,a(j)} = \alpha_0 + \alpha_1 ORG_{j,a(j)} + \alpha_2 D_{a(j)} + \alpha_3 E_{a(j)} + s_j + \epsilon_{j,a(j)}, \tag{6}$$

where all the variables have been previously defined. Consistent with the findings from subsections 5.2 and 6.2, in equation (6) both the density of employment areas and the number of layers in firms have an effect on the amount of wage dispersion in firms. Moreover, the findings from subsection 6.1 indicate firms in denser employment areas organize with a greater number of layers. Substituting this relationship into equation (6) yields:

$$\log I_{j,a(j)} = (\alpha_0 + \alpha_0\gamma_0) + (\alpha_1\gamma_1 + \alpha_2)D_{a(j)} + (\alpha_1\gamma_2 + \alpha_3)E_{a(j)} + s_j^{'} + \epsilon_{j,a(j)}^{'}, \tag{7}$$

where $\alpha_1\gamma_1 + \alpha_2$ is the total effect of density on the wage dispersion in firms. This equation is identical to equation (4), which implies the following. First, $\alpha_1\gamma_1 + \alpha_2 = \beta_1$, the elasticity of within-firm wage dispersion with respect to the density of employment areas. And second, the density elasticity is sum of two components. The term $\alpha_1\gamma_1$ is an indirect effect and measures the extent density has an effect on wage dispersion, through differences in the way firms organize production. The second term, α_2, is the direct effect of density on the dispersion in firms. Furthermore, the magnitudes of most coefficients have been documented in previous sections. The only parameter that has not been estimated is the direct effect, α_2. This can be obtained by estimating equation (6), or it can be calculated from the other parameters: $\alpha_2 = \beta_1 - \alpha_1\gamma_1$. Here, I simply use the latter approach.[18]

[18] The results from this study parallel the mediation analysis literature, where the exogenous variable (X) is the density of employment areas, the mediator variable (M) is the number of layers in firms, and the outcome variable (Y) is the wage dispersion in firms. In this framework, I identify a causal relationship between X and M, and X and Y. However, because equation (5) reports correlations, I cannot claim to be able to identify a causal relationship between M and Y. As a result, I cannot use the statistical tests from the mediation analysis literature (see for example Sobel (1982), MacKinnon et al. (2002) and MacKinnon et al. (2012)). For this to be the case, one of the following must hold: (i) the organization of firms would have to either be an exogenous variable, (ii) organization entirely accounts for the density elasticity, and so the predicted values from equation (4) can be used an instruments (Holland (1988)), or (iii) there exists an exogenous variable that is related to the organization of firms but not with the wage dispersion in firms.

Table 9 reports results. Each column of the table decomposes the density elasticity into its direct and indirect components, from the different specifications used in this study. In Columns 1-3 the dependent variable is my baseline measure of wage dispersion, the variance of log hourly net wages within firms. Column 1 reports decomposition results from the most basic specification in this study, which only controls for the density of employment areas. The density elasticity is equal to 0.113, implying that a 1% increase in density is roughly associated with a 11.3% increase in the dispersion of wages in firms. Some of this increase is from the effect density has on the organization of firms. Column 1 indicates the indirect effect is equal to 0.035. The reasoning is the following. A 1% increase in density is associated with 0.047 additional layers, and each 0.01 additional layer is approximately associated with a 0.747 increase in the wage dispersion in firms. Together both results imply that a 1% increase in density is associated with a 3.5% ($\approx 0.047 * 0.747$) increase in the variance of log hourly net wages, which is simply from firms in denser employment areas organizing with a greater number layers. In other words, the spatial differences in the way firms organize production accounts for approximately 31.0% ($\approx 0.035/0.113$) of the relationship between the variance of log hourly net wages in firms and the density of employment areas.[19]

Columns 2 and 3 perform the same decomposition using specifications that control for the characteristics of employment areas. Column 2 reports results from specifications that control for the market potential, the economic composition and the endowments of areas. The findings are similar, and the organization of firms remains important for understanding the greater wage dispersion observed in firms in denser areas. Column 3 further reports decomposition results from specifications that also control for the demographic characteristics of employment areas. The magnitude of the density elasticity is 0.064 and the indirect effect is equal to 0.028 ($\approx 0.037 * 0.747$), implying the spatial differences in the organization of firms accounts for approximately 43.8% ($\approx 0.028/0.064$) of the relationship between the wage dispersion in firms and the density of employment areas.

The remaining columns of Table 9 report decomposition results, from specifications of wage

Neither of these conditions hold. Additionally, Dippel et al. (2017) present conditions under which a single instrument is sufficient for the identification of causal effects. These conditions also don't hold in this setting. Moreover, with respect to this mediation analysis literature, the most I can claim is that the results are consistent with a mediation model (Kraemer et al. (2001)).

[19]Note that results from equation (4) have larger samples. Some firms in equation (3) and (5) are dropped from the sample because their variance of wages is equal to zero. In most cases, even though the samples are different the point estimates remain the same. Whenever there is a discrepancy in results, I have re-estimated equation (4) on the same sample of firms as in the equations (3) and (5), and reported results based on those coefficients. See table notes for details.

dispersions that are based on different groups of workers and measures of incomes. The conclusion are the same, and organization continues to be important for understanding the spatial disparities within firms. For instance, Column 9 indicates that approximately 46.9% ($\approx 0.023/0.049$) of the relationship between the residual wage dispersion in firms and density of employment areas is accounted for by differences in the organization of firms.

In the Appendix, Tables A10 and A11 report additional results. Table A10 reports the same type of decomposition from the robustness exercises that consider different samples of firms. Differences in the organization of firms accounts for approximately 41.9% to 46.4% of the density elasticity. Further, Table A11 reports decompositions from robustness specifications that control for the characteristics of firms. In Table A11, the organization of firms accounts for approximately 21.7% to 25.5% of the relationship between the wage dispersion in firms and the density of employment areas.

Furthermore, Columns 1-4 of Table A12 further reports results from measures of disparities based on the 95-5 wage and earnings differentials in firms. The conclusions remain the same. The organization of firms accounts for approximately 40.0% to 55.0% of the density elasticity. Additionally, the last two columns suggest spatial differences in the organization of firms accounts for a greater share of the disparities in the higher layers of firms. Column 5 reports that spatial differences in the number of layers in firms accounts for 69.2% of the increasing relationship between the density of areas and the 95-50 log hourly wage gap in firms, while Column 6 reports that these same spatial differences account for 28.6% of the increasing 50-5 log hourly wage gap observed in denser areas. Again this is expected because the knowledge-based management models of Garicano (2000) argue that the benefits of additional layers are not equally shared among all workers in firms. In particular, the models indicate that an extra layers leads to wage increases for the most for productive workers, located in the highest layers of firms.

To summarize, the findings from this subsection indicate that one reason there are greater disparities in denser areas, is because firms adopt different organizational structures. The results from the subsection indicate the organization of firms accounts for approximately 21.7% to 46.4% of the increasing relationship between the within-firm variance of log hourly net wages and the density of employment areas. More generally, the findings suggest the organization of firms accounts for approximately 20.8% to 55.0% of the increasing disparities in firms located in denser employment areas. The mechanism examined in this study has not been explored in the urban literature, however, the evidence suggests it is important for understanding the nature and

Table 9: Density Elasticity Decomposition - Direct vs Indirect Effects

	Hourly Net Wages (1)	Hourly Net Wages (2)	Hourly Net Wages (3)	Full-Time Workers (4)	Full-Time Male Workers (5)	Hourly Gross Wages (6)	Net Earnings (7)	Gross Earnings (8)	Residual Wages I (9)	Residual Wages II (10)
Total Effect	0.113	0.108	0.064	0.084	0.078	0.068	0.024	0.022	0.049	0.040
Direct Effect	0.079	0.075	0.036	0.055	0.045	0.040	0.019	0.017	0.026	0.020
Indirect Effect	0.035	0.033	0.028	0.030	0.034	0.028	0.005	0.005	0.023	0.018
% of Direct Effect	69.0	69.4	56.2	64.3	56.4	58.8	79.2	77.3	53.2	55.0
% of Indirect Effect	31.0	30.6	43.8	35.7	43.6	41.2	20.8	22.7	46.9	45.0
Market Potential	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Employment Diversity	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Endowment Controls	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Demographic Controls	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: Total Effect refers to the density elasticity: $\alpha_1\gamma_1 + \alpha_2$ or β_1 from Tables 4 and 5. Direct Effect refers to estimates of the coefficient: α_2. These are directly calculated from the formula: $\alpha_2 = \beta_1 - \alpha_1\gamma_1$. Indirect Effect refers to estimates of: $\alpha_1\gamma_1$. Values of α_1 is from Table 8, and for Columns 1, 2, and 3, values of γ_1 are from Table 7. In Columns 4-10, I re-estimate equation (4) on the same sample of firms, as in Table 5. This yields estimates of γ_1 that are equal to 0.039, 0.041, 0.037, 0.037, 0.037, 0.037 *and* 0.037, *respectively. Industry fixed effects at the four-digit NAF Rev 1 level. Demographic controls are the following: the share of foreign-born individuals residing in an area, the fraction of the local population over the age of 25 with a university degree, as well as the share unemployed individuals in a local area.*

sources of spatial inequalities.

7 Conclusion

This paper has examined how the wage dispersion within firms varies with the density of areas and provided evidence in support of a new mechanism that explains spatial wage inequalities: differences in the organization of firms. The evidence indicates that one reason there is greater wage dispersion in denser areas is because firm organize with a greater number of hierarchical layers. The findings from this study show that a substantial share of the dispersion of wages is within firms, that this dispersion increases with the density of areas, that firms in denser areas organize with a greater number of layers, and that the dispersion of wages is greater in firms with more hierarchical layers. Moreover, the final part of the paper assesses the extent spatial differences in the way firms organize production contributes to the greater wage disparities observed in denser employment areas. Differences in the way firms organize production accounts for approximately 20.8% to 55.0% of the relationship between the dispersion of wages within firms and the density of areas.

The results from this paper are consistent with a number of studies. First, they are consistent with the theoretical literature on knowledge-based management hierarchies, which argues that the outcomes of workers depend on the organization of firms, as well as workers' position within firms (Garicano (2000), Garicano and Rossi-Hansberg (2006), and Caliendo and Rossi-Hansberg (2012)). Second, within this literature they are in agreement with a group studies that document there is greater wage dispersion in firms operating with a greater number of layers (see for example Caliendo et al. (2012) and Friedrich (2015)). And third, they are also consistent with the recent work by Spanos (2017) who empirically shows that service firms in denser areas have more layers.

More generally, the set of results from this study also provides avenues for future research. One of the contributions of the paper is to document that a substantial of share of the dispersion in wages within employment areas is within firms. This finding suggests that firms are important for understanding the outcomes of workers across local areas. This study has focused on one characteristic of firms that explains part of the spatial aspects of wage disparities. Hopefully, future research will continue to pursue this line of thought and explore other aspects of firms that have an effect on the outcomes of workers across local areas.

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ONLINE APPENDIX - For Online Publication

A Appendix: Additional Empirical Results

Table A1: Robustness II - Variance within Firms and Density

Dependent Variable: Variance of Log Hourly Net Wages (in logs)	All Firms Operating in a Single Area (1)	All Firms With at least 90% of Workers in an Area (2)	All Firms With at least 4 Employees (3)	All Firms With 4+ Employees and Operating in a Single Area (4)	Single Establishment Firms (5)
log density	0.115	0.114	0.065	0.069	0.062
	$(0.016)^a$	$(0.016)^a$	$(0.011)^a$	$(0.011)^a$	$(0.013)^a$
Method	OLS	OLS	OLS	OLS	OLS
R-squared	0.158	0.160	0.248	0.240	0.221
Sample Size	113,863	115,662	89,874	82,727	63,330
Market Potential	Y	Y	Y	Y	Y
Employment Diversity	Y	Y	Y	Y	Y
Endowment Controls	Y	Y	Y	Y	Y
Demographic Controls	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y

Notes: a,b,c: significant at the 1%, 5% and 10% level. Standard errors clustered at the employment area level. Dependent variable is the variance of log hourly net wages (in logs). Industry fixed effects at the four-digit NAF Rev 1 level. Demographic controls are the following: the share of foreign-born individuals residing in an area, the fraction of the local population over the age of 25 and with a university degree, as well as the share unemployed individuals in a local area.

Table A2: Robustness III - Variance within Firms and Density

Dependent Variable: Variance of Log Hourly Net Wages (in logs)	(1)	(2)	(3)	(4)	(5)
log density	0.048	0.049	0.046	0.047	0.045
	$(0.013)^a$	$(0.013)^a$	$(0.013)^a$	$(0.012)^a$	$(0.011)^a$
Method	OLS	OLS	OLS	OLS	OLS
R-squared	0.279	0.279	0.283	0.296	0.332
Sample Size	66,975	66,975	66,975	63,064	63,064
Market Potential	Y	Y	Y	Y	Y
Employment Diversity	Y	Y	Y	Y	Y
Endowment Controls	Y	Y	Y	Y	Y
Demographic Controls	Y	Y	Y	Y	Y
Firm Size	Y	Y	Y	Y	Y
Export Status	N	Y	Y	Y	Y
Additional Occupations	N	N	Y	Y	Y
Capital	N	N	N	Y	Y
Legal Status	N	N	N	N	Y
Industry FE	Y	Y	Y	Y	Y

Notes: a,b,c: significant at the 1%, 5% and 10% level. Standard errors clustered at the employment area level. Dependent variable is the variance of log hourly net wages (in logs). Industry fixed effects at the four-digit NAF Rev 1 level. Demographic controls are the following: the share of foreign-born individuals residing in an area, the fraction of the local population over the age of 25 and with a university degree, as well as the share unemployed individuals in a local area. Firm size is equal to the natural log of total number of hours in a firm. The number of additional occupation is measured as the natural log of: the number of occupations in firms minus the number of layers in firms + 1. Capital is the natural log of the value of amount of property and equipment in firms.

Table A3: Robustness IV - Wage Gaps within Firms and Density

	95-5 Gaps				95-50 Gaps	50-5 Gaps
	Net Hourly Wages (1)	Gross Hourly Wages (2)	Net Earnings (3)	Gross Earnings (4)	Net Hourly Wages (5)	Net Hourly Wages (6)
log density	0.020	0.023	0.025	0.023	0.013	0.007
	$(0.004)^a$	$(0.005)^a$	$(0.011)^b$	$(0.011)^b$	$(0.003)^a$	$(0.002)^a$
Method	OLS	OLS	OLS	OLS	OLS	OLS
R-squared	0.207	0.208	0.041	0.041	0.141	0.196
Sample Size	66,983	66,983	66,983	66,983	66,983	66,983
Market Potential	Y	Y	Y	Y	Y	Y
Employment Diversity	Y	Y	Y	Y	Y	Y
Endowment Controls	Y	Y	Y	Y	Y	Y
Demographic Controls	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y

Notes: a,b,c: significant at the 1%, 5% and 10% level. Standard errors clustered at the employment area level. Dependent variable is the variance of log hourly net wages (in logs). Industry fixed effects at the four-digit NAF Rev 1 level. Demographic controls are the following: the share of foreign-born individuals residing in an area, the fraction of the local population over the age of 25 and with a university degree, as well as the share unemployed individuals in a local area.

Table A4: Robustness I - Organization and Density

Dependent Variable: Number of Layers	All Firms Operating in a Single Area (1)	All Firms With at least 90% of Workers in an Area (2)	All Firms With at least 4 Employees (3)	All Firms With 4+ Employees and Operating in a Single Area (4)	Single Establishment Firms (5)
log density	0.058	0.058	0.043	0.046	0.035
	(0.006)[a]	(0.006)[a]	(0.007)[a]	(0.007)[a]	(0.008)[a]
Method	OLS	OLS	OLS	OLS	OLS
R-squared	0.270	0.273	0.349	0.343	0.323
Sample Size	138, 205	140, 008	89, 883	82, 736	63, 338
Market Potential	Y	Y	Y	Y	Y
Employment Diversity	Y	Y	Y	Y	Y
Endowment Controls	Y	Y	Y	Y	Y
Demographic Controls	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y

Notes: a,b,c: significant at the 1%, 5% and 10% level. Dependent variable is the number of layers in firms. Industry fixed effects at the four-digit NAF Rev 1 level. Demographic controls are the following: the share of foreign-born individuals residing in an area, the fraction of the local population over the age of 25 and with a university degree, as well as the share unemployed individuals in a local area.

Table A5: Robustness II - Organization and Density

Dependent Variable: Number of Layers	(1)	(2)	(3)	(4)	(5)
log density	0.016	0.017	0.014	0.016	0.015
	(0.007)[b]	(0.007)[b]	(0.007)[b]	(0.007)[b]	(0.006)[b]
Method	OLS	OLS	OLS	OLS	OLS
R-squared	0.498	0.500	0.510	0.519	0.558
Sample Size	66, 983	66, 983	66, 983	63, 071	63, 071
Market Potential	Y	Y	Y	Y	Y
Employment Diversity	Y	Y	Y	Y	Y
Endowment Controls	Y	Y	Y	Y	Y
Demographic Controls	Y	Y	Y	Y	Y
Firm Size	Y	Y	Y	Y	Y
Export Status	N	Y	Y	Y	Y
Additional Occupations	N	N	Y	Y	Y
Capital	N	N	N	Y	Y
Legal Status	N	N	N	N	Y
Industry FE	Y	Y	Y	Y	Y

Notes: a,b,c: significant at the 1%, 5% and 10% level. Standard errors clustered at the employment area level. Dependent variable is the number of layers in firms. Industry fixed effects at the four-digit NAF Rev 1 level. Demographic controls are the following: the share of foreign-born individuals residing in an area, the fraction of the local population over the age of 25 and with a university degree, as well as the share unemployed individuals in a local area. Firm size is equal to the natural log of total number of hours in a firm. The number of additional occupation is measured as the natural log of: the number of occupations in firms minus the number of layers in firms + 1. Capital is the natural log of the value of amount of property and equipment in firms.

Table A6: Robustness I - Variance within Firms and Organization

	Hourly Net Wages (1)	Full-Time Workers (2)	Full-Time Male Workers (3)	Hourly Gross Wages (4)	Net Earnings (5)	Gross Earnings (6)	Residual Wages I (7)	Residual Wages II (8)
organization	0.740	0.748	0.803	0.749	0.142	0.141	0.616	0.491
	(0.018)[a]	(0.018)[a]	(0.017)[a]	(0.017)[a]	(0.009)[a]	(0.010)[a]	(0.010)[a]	(0.016)[a]
Method	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
R-squared	0.584	0.510	0.494	0.584	0.333	0.333	0.555	0.350
Sample Size	66,975	63,401	57,189	66,973	66,970	66,974	66,983	58,991
Area-Ind FE	Y	Y	Y	Y	Y	Y	Y	Y

Notes: a,b,c: significant at the 1%, 5% and 10% level. Standard errors clustered at the employment area level. Industry-Area fixed effects are based on the four-digit NAF Rev 1 levels and the 341 employment areas.

Table A7: Robustness II - Variance within Firms and Organization

Dependent Variable: Variance of Log Hourly Net Wages (in logs)	All Firms Operating in a Single Area (1)	All Firms With at least 90% of Workers in an Area (2)	All Firms With at least 4 Employees (3)	All Firms With 4+ Employees and Operating in a Single Area (4)	Single Establishment Firms (5)
organization	0.949	0.942	0.681	0.696	0.749
	(0.014)[a]	(0.014)[a]	(0.009)[a]	(0.010)[a]	(0.011)[a]
Method	OLS	OLS	OLS	OLS	OLS
R-squared	0.325	0.328	0.451	0.442	0.427
Sample Size	113,863	115,662	89,874	82,727	63,330
Area FE	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y

Notes: a,b,c: significant at the 1%, 5% and 10% level. Standard errors clustered at the employment area level. Dependent variable is the variance of log hourly net wages (in logs). Industry fixed effects at the four-digit NAF Rev 1 level.

Table A8: Robustness III - Variance within Firms and Organization

Dependent Variable: Variance of Log Hourly Net Wages (in logs)	(1)	(2)	(3)	(4)	(5)
organization	0.736	0.735	0.733	0.720	0.679
	(0.010)[a]	(0.010)[a]	(0.010)[a]	(0.011)[a]	(0.010)[a]
Method	OLS	OLS	OLS	OLS	OLS
R-squared	0.429	0.429	0.429	0.439	0.450
Sample Size	66,975	66,975	66,975	63,064	63,064
Area FE	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y
Firm Size	Y	Y	Y	Y	Y
Export Status	N	Y	Y	Y	Y
Additional Occupations	N	N	Y	Y	Y
Capital	N	N	N	Y	Y
Legal Status	N	N	N	N	Y
Industry FE	Y	Y	Y	Y	Y

Notes: a,b,c: significant at the 1%, 5% and 10% level. Standard errors clustered at the employment area level. Dependent variable is the variance of log hourly net wages (in logs). Industry fixed effects at the four-digit NAF Rev 1 level. Firm size is equal to the natural log of total number of hours in a firm. The number of additional occupation is measured as the natural log of: the number of occupations in firms minus the number of layers in firms + 1. Capital is the natural log of the value of amount of property and equipment in firms.

Table A9: Robustness IV - Wage Gaps within Firms and Density

	95-5 Gaps				95-50 Gaps	50-5 Gaps
	Net Hourly Wages (1)	Gross Hourly Wages (2)	Net Earnings (3)	Gross Earnings (4)	Net Hourly Wages (5)	Net Hourly Wages (6)
log density	0.302	0.311	0.280	0.272	0.242	0.059
	(0.003)[a]	(0.003)[a]	(0.008)[a]	(0.008)[a]	(0.002)[a]	(0.003)[a]
Method	OLS	OLS	OLS	OLS	OLS	OLS
R-squared	0.465	0.465	0.073	0.072	0.373	0.271
Sample Size	66,983	66,983	66,983	66,983	66,983	66,983
Area FE	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y

Notes: a,b,c: significant at the 1%, 5% and 10% level. Standard errors clustered at the employment area level. Industry fixed effects at the four-digit NAF Rev 1 level.

Table A10: Robustness I - Density Elasticity Decomposition - Direct vs Indirect Effects

Dependent Variable: Variance of Log Hourly Net Wages (in logs)	All Firms Operating in a Single Area (1)	All Firms With at least 90% of Workers in an Area (2)	All Firms With at least 4 Employees (3)	All Firms With 4+ Employees and Operating in a Single Area (4)	Single Establishment Firms (5)
Total Effect	0.115	0.114	0.065	0.069	0.062
Direct Effect	0.063	0.063	0.036	0.037	0.036
Indirect Effect	0.052	0.051	0.029	0.032	0.026
% of Direct Effect	54.8	55.3	55.4	53.6	58.1
% of Indirect Effect	45.2	44.7	44.6	46.4	41.9
Market Potential	Y	Y	Y	Y	Y
Employment Diversity	Y	Y	Y	Y	Y
Endowment Controls	Y	Y	Y	Y	Y
Demographic Controls	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y

Notes: Total Effect refers to the density elasticity: $\alpha_1\gamma_1 + \alpha_2$ or β_1 from Table A1. Direct Effect refers to estimates of the coefficient: α_2. These are directly calculated from the formula: $\alpha_2 = \beta_1 - \alpha_1\gamma_1$. Indirect Effect refers to estimates of: $\alpha_1\gamma_1$. Values of α_1 is from Table A7, and for Columns 3, 4, and 5, values for γ_1 is from Table A4. In Columns 1, and 2, I re-estimate equation (4) on the same sample of firms as in Table A1. This yields estimates of γ_1 that are equal to 0.055, and 0.054. Industry fixed effects at the four-digit NAF Rev 1 level. Demographic controls are the following: the share of foreign-born individuals residing in an area, the fraction of the local population over the age of 25 and with a university degree, as well as the share unemployed individuals in a local area.

Table A11: Robustness II - Density Elasticity Decomposition - Direct vs Indirect Effects

Dependent Variable: Variance of Log Hourly Net Wages (in logs)	(1)	(2)	(3)	(4)	(5)
Total Effect	0.048	0.049	0.046	0.047	0.045
Direct Effect	0.036	0.037	0.036	0.035	0.035
Indirect Effect	0.012	0.012	0.010	0.012	0.010
% of Direct Effect	75.0	75.5	78.3	74.5	77.8
% of Indirect Effect	25.0	24.5	21.7	25.5	22.2
Market Potential	Y	Y	Y	Y	Y
Employment Diversity	Y	Y	Y	Y	Y
Endowment Controls	Y	Y	Y	Y	Y
Demographic Controls	Y	Y	Y	Y	Y
Firm Size	Y	Y	Y	Y	Y
Export Status	N	Y	Y	Y	Y
Additional Occupations	N	N	Y	Y	Y
Capital	N	N	N	Y	Y
Legal Status	N	N	N	N	Y
Industry FE	Y	Y	Y	Y	Y

Notes: Total Effect refers to the density elasticity: $\alpha_1\gamma_1 + \alpha_2$ or β_1 from Table A2. Direct Effect refers to estimates of the coefficient: α_2. These are directly calculated from the formula: $\alpha_2 = \beta_1 - \alpha_1\gamma_1$. Indirect Effect refers to estimates of: $\alpha_1\gamma_1$. Values of α_1 is from Table A8, and values for γ_1 is from Table A5. In Column 5, I re-estimate equation (4) on the same sample of firms as in Table A2. This yields an estimate of γ_1 equal to 0.014. Industry fixed effects at the four-digit NAF Rev 1 level. Demographic controls are the following: the share of foreign-born individuals residing in an area, the fraction of the local population over the age of 25 and with a university degree, as well as the share unemployed individuals in a local area. Firm size is equal to the natural log of total number of hours in a firm. The number of additional occupation is measured as the natural log of: the number of occupations in firms minus the number of layers in firms + 1. Capital is the natural log of the value of amount of property and equipment in firms.

Table A12: Robustness III - Density Elasticity Decomposition - Direct vs Indirect Effects

	95-5 Gaps				95-50 Gaps	50-5 Gaps
	Net Hourly Wages (1)	Gross Hourly Wages (2)	Net Earnings (3)	Gross Earnings (4)	Net Hourly Wages (5)	Net Hourly Wages (6)
Total Effect	0.020	0.023	0.025	0.023	0.013	0.007
Direct Effect	0.009	0.011	0.015	0.013	0.004	0.005
Indirect Effect	0.011	0.012	0.010	0.010	0.009	0.002
% of Direct Effect	45.0	47.8	60.0	56.5	30.8	71.4
% of Indirect Effect	55.0	52.2	40.0	43.5	69.2	28.6
Market Potential	Y	Y	Y	Y	Y	Y
Employment Diversity	Y	Y	Y	Y	Y	Y
Endowment Controls	Y	Y	Y	Y	Y	Y
Demographic Controls	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y

Notes: Total Effect refers to the density elasticity: $\alpha_1\gamma_1 + \alpha_2$ or β_1 from Table A3. Direct Effect refers to estimates of the coefficient: α_2. These are directly calculated from the formula: $\alpha_2 = \beta_1 - \alpha_1\gamma_1$. Indirect Effect refers to estimates of: $\alpha_1\gamma_1$. Values of α_1 is from Table A7, and values for γ_1 is from Table 7. Industry fixed effects at the four-digit NAF Rev 1 level. Demographic controls are the following: the share of foreign-born individuals residing in an area, the fraction of the local population over the age of 25 and with a university degree, as well as the share unemployed individuals in a local area.

B Appendix: Classification Checks

Table B1: Statistics of Organizations - Percent of Firms that Satisfy Hierarchy Conditions

Panel A: Number of Workers	$N_L^l \leq N_L^{l-1}, \forall l$	$N_L^2 \leq N_L^1$	$N_L^3 \leq N_L^2$	$N_L^4 \leq N_L^3$
Total Number of Layers				
Two-Layers	0.914	0.914	–	–
Three-Layers	0.744	0.876	0.856	–
Four-Layers	0.690	0.898	0.821	0.955
Panel B: Number of Hours	$HR_L^l \leq HR_L^{l-1}, \forall l$	$HR_L^2 \leq HR_L^1$	$HR_L^3 \leq HR_L^2$	$HR_L^4 \leq HR_L^3$
Total Number of Layers				
Two-Layers	0.871	0.871	–	–
Three-Layers	0.577	0.830	0.718	–
Four-Layers	0.484	0.863	0.748	0.802
Panel C: Net Wages per Hour	$w_L^{l-1} \leq w_L^l, \forall l$	$w_L^1 \leq w_L^2$	$w_L^2 \leq w_L^3$	$w_L^3 \leq w_L^4$
Total Number of Layers				
Two-Layers	0.897	0.897	–	–
Three-Layers	0.809	0.906	0.901	–
Four-Layers	0.715	0.941	0.917	0.835
Panel D: Gross Wages per Hour	$w_L^{l-1} \leq w_L^l, \forall l$	$w_L^1 \leq w_L^2$	$w_L^2 \leq w_L^3$	$w_L^3 \leq w_L^4$
Total Number of Layers				
Two-Layers	0.899	0.899	–	–
Three-Layers	0.809	0.904	0.903	–
Four-Layers	0.716	0.939	0.922	0.830
Panel E: Net Wages per Worker	$w_L^{l-1} \leq w_L^l, \forall l$	$w_L^1 \leq w_L^2$	$w_L^2 \leq w_L^3$	$w_L^3 \leq w_L^4$
Total Number of Layers				
Two-Layers	0.797	0.797	–	–
Three-Layers	0.644	0.817	0.811	–
Four-Layers	0.563	0.877	0.824	0.800
Panel F: Gross Wages per Worker	$w_L^{l-1} \leq w_L^l, \forall l$	$w_L^1 \leq w_L^2$	$w_L^2 \leq w_L^3$	$w_L^3 \leq w_L^4$
Total Number of Layers				
Two-Layers	0.798	0.798	–	–
Three-Layers	0.648	0.818	0.814	–
Four-Layers	0.563	0.878	0.830	0.794

Notes: Checks that classification of workers into layers is consistent. Percent of firms that satisfy the conditions of hierarchical organizations. Panels A and B measure the percent of firms that satisfy the condition that lower layers are larger than higher layers. In Panel A the size of layer is measured using workers. In Panel B the size of layer is measures using hours. Panels C, D, E and F measure the percent of firms that satisfy the condition that lower layers earn lower earnings per unit of labor than higher layers. In Panel C earnings per unit of labor are measured as the total net wage bill in a layer divided by the number of hours in that layer. In Panel D earnings per unit of labor are measured as the total gross wage bill in a layer divided by the number of hours in that layer. In Panel E earnings per unit of labor are measured as the total net wage bill in a layer divided by the number of workers in that layer. In Panel E earnings per unit of labor are measured as the total gross wage bill in a layer divided by the number of workers in that layer.