The Internal Spatial Organization of Firms: Evidence from Denmark*

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First version: April 15, 2018
This version: November 27, 2020

WORKING PAPER

Abstract

We study the location and occupational composition of establishments within firms between 1981 and 2016. Using Danish administrative employer-employee matched data, we document four interesting results regarding the internal spatial organization of firms. First, we show that the average number of establishments per firm increased by 21%. Second, the average distance of establishments and workers from their headquarters increased by around 100%. Third, these changes are mainly driven by the decentralization of production and business service workers and higher use of the latter. Fourth, we show that the ratio of managers to production and clerical workers within firms increased by 45%, driven particularly by headquarters and establishments located in the largest cities. These facts imply that firms are not simply becoming more spatially dispersed; instead, some activities, such as managerial, are increasingly being concentrated near firms' central offices.

JEL: L22, L23, R00, R30.

Keywords: spatial organization, agglomeration, multi-establishment firms, firm fragmentation, occupational composition.

*We would like to thank the editor, Gilles Duranton; the two anonymous referees; Nathaniel Baum-Snow, Bernardo Blum, Daniel Broxterman, Rolando Campusano, Høgni Kalsø Hansen, Ignatius Horstmann, José Martínez, Ismir Mulalic, William Strange, and Cecilie Dohlmann Weatherall for their valuable comments, as well as participants at the 2018 Canadian Economic Association meetings, 2018 UEA Meetings, Kraks Fond Seminars, and the University of Toronto International Economics Seminars. We also thank the Kraks Fond - Institute for Urban Economic Research and the Rotman School of Management for their financial support.

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1 Introduction

In 1890, Alfred Marshall documented that cities and regions often specialize by sector. He argued that labor market pooling, input sharing, and knowledge spillovers lead to specialization and the rise of agglomeration economies (Marshall, 1890).[1] More recently, Duranton and Puga (2005) argue that the pattern of specialization is shifting from sectoral to functional. Specifically, they show an increasing concentration of managerial occupations in large relative to small cities, relative to production occupations. They contend that changes in the organization of firms—led by decreases in the costs of remote management—could be behind this transformation. The spatial organization of activities within firms also plays an important role in influencing other regional differences, such as the variation of wages across labor markets.[2] Therefore, understanding the internal spatial organization of firms is essential in understanding different spatial phenomena and the position of a city in the country's labor market.

In this paper, we study the internal spatial organization of firms. In particular, we study how the location and labor composition of different establishments within firms have changed in the last four decades. Understanding these facts is relevant, given the importance of multi-establishment (ME) firms in the aggregate economy. Even though only 7% of all private firms in Denmark have more than one establishment, these firms account for around 47% of all private sector employment and 54% of total output revenue, and have lower exit rates. Studying the changes in the spatial organization of these firms is a necessary first step before addressing questions concerning the causes and consequences of such organizational structures.

We study these spatial organizational patterns using Danish administrative data between 1981 and 2016. These data contain all matches between employees and establishments every year, and therefore we are able to follow every worker through every job they have had since 1981. Since the data have unique firm, establishment, and worker identifiers, we can determine whether a firm has one or multiple establishments and characterize each establishment based on its workers' characteristics. Moreover, we observe the location of establishments at the traffic zone level; these areas are significantly smaller than municipalities. These detailed locations allow us to compute more precise measures of firm decentralization without making strong assumptions regarding the location of establishments within a municipality, as has been common in the literature.

Using these data, we lay out four facts that describe the spatial organization of firms. Some of these facts are, to the best of our knowledge, new in the literature and represent the main contribution of this paper. First, we show that the average number of establishments within a firm increased by 21% between 1981 and 2016. This increase in firm fragmentation holds for all four aggregate sectors in our sample: manufacturing; finance, insurance, and real estate; business services; and transportation. Second, we document an increase of around 100% in

[1] See Combes and Gobillon (2015) for a recent survey of the literature on patterns of specialization and agglomeration economies.

[2] For instance, Spanos (2017) finds that differences in the internal organization of firms can explain between 22% and 46% of the variation of wages across labor markets.

the average distance between firms' establishments and their headquarters (HQ). This implies an increase in the spatial decentralization within firms over time. Specifically, it implies that firms are either replacing establishments that are closer to their HQ with establishments farther away or opening new ones farther from the HQ. This increase holds when we weight each establishment by its share of employment within the firm, which suggests that even if some firms did not open or close establishments during our sample period, they could be reallocating some of their jobs farther from the HQ.

Third, the increase in the average distance to the HQ is driven mainly by two trends. First, an increase in the average distance of workers in production, engineering, and business services occupations. Second, an increase in the use of business services workers and a decrease in the use of clerical and production workers. In addition, we find that the increase in the average distance to the HQ of managerial occupations has been relatively small and their use has increased. This results points the existence of strong within-firm agglomeration economies for some high-skilled occupations. Fourth, we show that the ratio of managers to production and clerical workers within firms has increased. In particular, the size of the average production team within firms has decreased by 45%. This decrease has been particularly large in HQ establishments and in establishments located in Copenhagen and Aarhus. Finally, we show that the increase in functional specialization observed in the data is partially driven by the location and labor demand decisions of ME firms, as suggested by Duranton and Puga (2005).

All of these facts suggest that while firms are becoming more spatially dispersed and their geographic span of control broader, the degree of decentralization is not the same across all of the firm's activities. In particular, this decentralization is happening mostly for production and business services activities, while there is an increasing relative concentration of managerial activities around the firms' central offices. These facts imply that firms are fragmenting into functions. Furthermore, given the deepening connection between geography and the internal organization of firms, our results suggest that the study of spatial and urban phenomena and the economics of organizations would be increasingly incomplete if they do not take each other into consideration.

This paper relates to the literature that studies the location decisions of ME HQ and the agglomeration of headquarters (Aarland et al., 2007; Davis and Henderson, 2008; Henderson and Ono, 2008; Strauss-Kahn and Vives, 2009; Mota and Brandão, 2013; Alcácer and Delgado, 2016; Bartelme and Ziv, 2017; Oberfield et al., 2020). In particular, Henderson and Ono (2008) suggest that it is quite costly for firms to locate their first stand-alone HQ distant from their production facilities, given communication and coordination costs. Thus, a new location has to offer something beneficial for the firm, such as a larger variety of business services. Our analysis is also guided by some theoretical studies that examine firm fragmentation and location decisions (Ota and Fujita, 1993; Duranton and Puga, 2005; Rossi-Hansberg et al., 2009; Gokan et al., 2019). Most of the studies in this area focus on comparing firms' location choices—and some of their determinants—by comparing firms in the cross-section. Our paper contributes to this literature by being the first one to study changes in firm fragmentation and spatial decentralization over a long period.

Our paper also relates to research on the labor composition across different establishments within firms (Charnoz et al., 2018; Cestone et al., 2018; Antoni et al., 2019; Acosta and Lyngemark, 2020). To our knowledge, our paper is the first to empirically study changes in the internal spatial organization of firms along two equally important margins: the extensive margin, in terms of whether to have multiple establishments and their locations, and the intensive margin, with respect to the distribution of workers within firms. This allows us to understand the structure of firms and their possible effects on local economies in a more holistic way. Moreover, we show that changes in the spatial organization of firms can be behind the increases in functional specialization, as Duranton and Puga (2005) suggest.

The location of establishments and firms has been studied in other fields within economics and management sciences. First, there is a wide literature in management sciences that studies the development of multi-unit corporations and the role of corporate HQ, both within and across national borders. Some examples include Chandler (1969); Fligstein (1985); Collis et al. (2007); and Menz et al. (2015). Research in this area is usually based on qualitative studies or uses samples consisting of a few large firms. Our data, in contrast, cover the universe of firms within a country.

Second, there have been large advances in the international trade literature regarding the study of multinational enterprises (Antràs and Yeaple, 2014). We consider a firm's decision to become multinational to be a specific case of the firm fragmentation process. Third, there have been theoretical and empirical advances in the study of models of market entry in industrial organization (Holmes, 2011; Aguirregabiria and Suzuki, 2016). Among others, Atalay et al. (2014) study vertical integration and outsourcing decisions. Even though we consider these to be important margins of firm fragmentation, we take the boundaries of the firm as given due to data limitations. Finally, this paper contributes to the literature studying firm organization and its relation to communication costs (Becker and Murphy, 1992; Garicano, 2000). Our paper adds to this literature by highlighting the potential importance of geography in determining firm organization and corporate decisions, in line with Antràs et al. (2006); Landier et al. (2009); Kalnins and Lafontaine (2013); Antoni et al. (2019); and Spanos (2019).

The rest of the paper proceeds as follows. In Section 2, we describe aggregate trends of ME firms and describe our data. Section 3 presents our findings on the internal spatial organization of firms in Denmark, and Section 4 concludes.

2 Data Description

In this section we briefly describe the Danish labor market, especially in regard to ME firms. Afterward, we describe our main data sources and the data selection process.

2.1 Denmark

Approximately 5.7 million people lived in Denmark in 2016. Of this total, 53% were part of the labor force and there was an unemployment rate of 4.1%. The Danish labor market has been extensively studied both because of the superb quality of its micro data and because of the flexible labor regulations that characterize the country. Denmark has one of the lowest turnout rates in continental Europe and generous unemployment benefits, which are combined with strategies that provide strong incentives to search for jobs (Hummels et al., 2014; Dahl et al., 2013). This flexibility has allowed firms to better respond to different shocks and set wages that better reflect worker and firm characteristics. Although the link between these regulations and firm fragmentation remains unexplored, we believe that labor market flexibility allows firms to benefit from the comparative advantages that different markets offer, which encourages the spatial decentralization of activities.

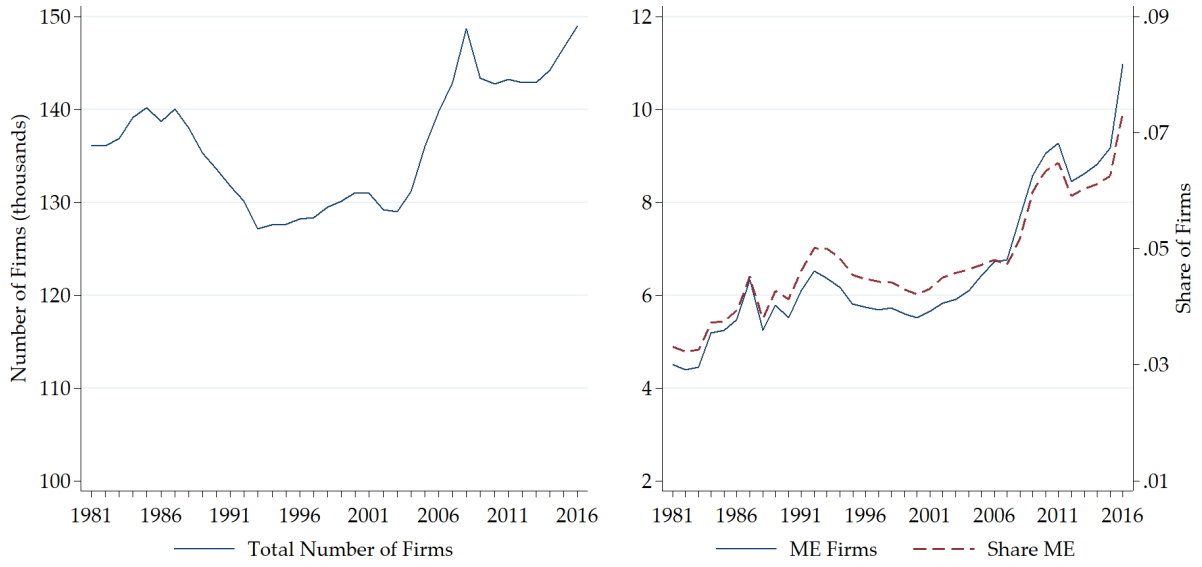
Regarding firms, Figure 1 shows the evolution of the total number of firms (left panel), and the total number and share of ME firms (right panel) in Denmark between 1981 and 2016. The figure shows that the total number of firms has been increasing since the early 1990s, with a small setback around the turn of the century and a larger one caused by the global recession of 2008. Today, there are around 150,000 firms in Denmark. The right panel of the figure shows that both the number and the share of ME firms in Denmark has been increasing since 1981. In particular, it went from 4,500 (3.3% of the total number of firms) to almost 11,000 firms (7.4%). The importance of ME firms also increased over our sample period. Panel A in Figure A1 shows that the share of employment generated by ME firms went from 39.5% in 1981 to 47.4% in 2016, while the share of aggregate production generated by them increased from 45.7% in 1999 to 54.2% in 2016.

Population and employment in Denmark are concentrated in the Copenhagen metropolitan area and the second largest city, Aarhus, which is located in Eastern Jutland. Other important urban areas include Odense, located in Funen, and Aalborg, located in North Jutland. Economic growth in these cities is mainly based on knowledge-intensive industries, such as the medical industry, and business services. Moreover, the rise of services and welfare economies have lead to strong growth in the demand for high-skilled jobs in these urban areas (Hansen and Winther, 2012). The metropolitan areas of these four municipalities account for around 34%, 15%, 10.5%, and 9% of the total population, respectively. Similarly, these cities host a disproportionate share of HQ, establishments, and workers belonging to ME firms. In particular, around 44.8%, 13.1%, 6.1%, and 5.9% of the ME firms in our sample have their HQ inside the metropolitan areas of Copenhagen, Aarhus, Odense and Aalborg, respectively.

2.2 Data Sources

Our data on firms, establishments, and workers come from several administrative registers in Statistics Denmark and contain the universe of employers and employees for the period 1981-2016. We start with the Integrated Database for Labor Market Research (IDA), which

Figure 1: Evolution of Multi-establishment Firms in Denmark



This figure shows the evolution of the total number of firms, total number of ME, and the share of ME firms in Denmark between 1981 and 2016.

contains all matches between employees and their workplaces every year. This register associates each establishment, firm, and worker with unique identifiers. Given these unique identifiers, we can determine whether a firm has one or multiple establishments and follow every worker through every employer they have worked for during their lifetime.[3] Equivalently, we observe the workers who belong to each establishment and the establishments that belong to each firm inside Denmark throughout this period.

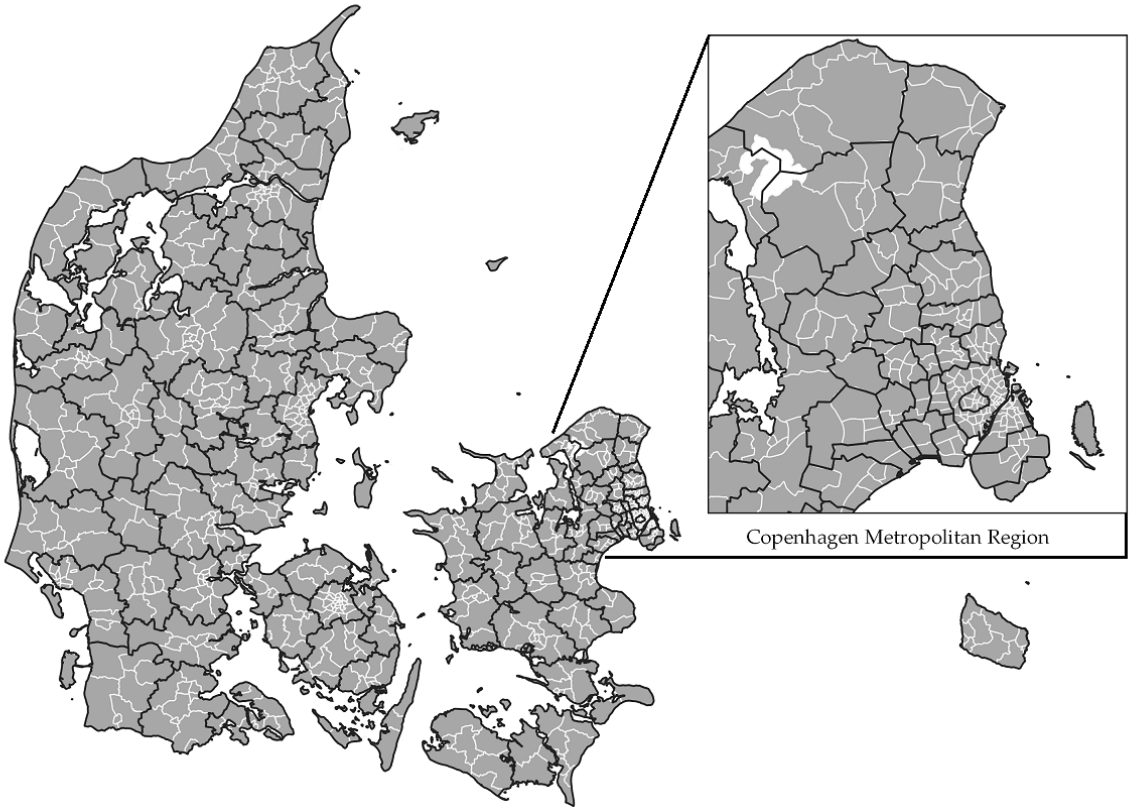
Even though the IDA reports the municipality in which establishments are located, municipalities outside the capital region are quite large. This level of aggregation implies that we would have to make strong assumptions regarding establishments' locations and the distance between them.[4] For this reason, we merged our data with a novel dataset containing the location of all establishments at the traffic zone level. Traffic zones are geographic areas smaller than municipalities and are defined by the National Transport Model (LTM). The LTM is developed by the Technical University of Denmark to "illustrate the overall traffic flow in Denmark" and provides "a tool for planning and investments in the transport system" (Technical University of Denmark, 2017). Figure 2 shows the 98 municipalities (black borders) and the 907 traffic zones (white borders), including a zoom-in image of the Copenhagen metropolitan area. On average,

[3]Statistics Denmark defines a firm as an administrative unit that is subject to registration by the Danish Customs and Tax Agency, regardless of its level of activity (Statistics Denmark, 2016). An establishment is defined as an individual local business unit, which is an organizationally defined part of a firm and is located at a given address (Statistics Denmark, 1991; Timmermans, 2010).

[4]For example, that establishments are located in the centroids of their municipalities and impute distance between establishments as distance between centroids.

there are 9.25 traffic zones in each municipality.[5] The average traffic zone has an extension of 47.3 square kilometers (km), compared with 424.3 square km of the average municipality.[6]

Figure 2: Municipalities and Traffic Zones in Denmark



This map shows the 98 municipalities (black borders) and the 907 traffic zones (white borders). Traffic zones are defined in the National Transport Model by the Technical University of Denmark. The box in the upper right zooms in on the metropolitan area of Copenhagen.

The LTM includes the distance and travel time between all pairs of traffic zones. These travel times take into account times within traffic zones, which are computed by taking into account the size and quality of roads and congestion. Therefore, travel times within traffic zones are not zero in our data. The average and median establishments of ME firms in Denmark are located 127 km (93 minutes) and 70 km (57 minutes) from their HQ, respectively; the maximum distance (travel time) between an establishment and its HQ is 788 km (810 minutes). This more detailed location of establishments represents a contribution of our paper in terms of data, since other studies on the topic only observe establishment location at the municipality or county level (Henderson and Ono, 2008; Charnoz et al., 2018; Antoni et al., 2019). Furthermore, this level of location allows us to provide more precise measures of firm decentralization. Using these locations, we define an establishment as the unique triplet between the establishment's

[5] In some empirical exercises, we use commuting areas as defined by Nielsen (2005).

[6] Some traffic zones inside the main cities have areas below 2.6 square km (1 square mile). In particular, there are 77 traffic zones within Copenhagen and Frederiksberg, with an average area of 1.3 square km. For comparison, counties in the US have an average area of 2,825 square km.

identifier, its location, and its firm identifier.

Besides establishments' sector and workers' wages, the IDA does not contain many other characteristics. Therefore, we merge the IDA with other registers. First, with the Labor Classification Module (AKM), which contains worker occupation. Specifically, we use both the PSTILL variable, which defines the primary job for each worker in terms of their job position, and the 4-digit DISCO88 code, which defines their detailed occupation and is only available from 1991.[7] For most of the analysis, we aggregate the 4-digit DISCO codes into 6 categories: managers, business services workers, engineers and scientists, clerical workers, production workers, and other workers.[8] We also include the worker's age and their highest completed education level from the Population and Education Statistics registers, respectively. Since workers may have several jobs in one year, we use each employee's main job, which is defined by Statistics Denmark based on the worker's main source of income. In addition, we drop workers younger than 15 years old and older than 80 years old. The inclusion of these variables implies that for each establishment of a ME firm, we can characterize its labor force in terms of workers' occupations (and, potentially, any other characteristics).

Second, we merge our database with firm records from the General Firm Statistics (FIRM) and the Accounting Statistics (FIRE), which are only available after 1997. From these registers, we are particularly interested in the value of production, total employment, and firm sector. In both registers, firms also report a location, which corresponds to the location of their HQ. For confidentiality reasons, we only observe this location at the municipality level. We categorize an establishment as the HQ establishment if its location is the same as the location reported by the firm and has at least five employees. Using this definition, we define a HQ establishment for 96% of the firms in our sample. The remaining 4% are firms that have more than one establishment in the same municipality as the one reported in their accounting records. In these cases, we take the establishments' labor composition into consideration and choose the establishment with the largest (i) number of managers, (ii) number of high wage earners, (iii) number of workers with master's or doctorate degree, and (iv) number of workers with technical or bachelor's degree.

An important caveat of our data worth mentioning is that we are not able to observe establishments that Danish firms might have outside Denmark or arm's-length transactions inside the country. It is clear that globalization has caused firms to increase offshoring and foreign and domestic outsourcing.[9] Therefore, our results should probably be interpreted as a lower bound of the actual decentralization and specialization patterns within firms.

[7] DISCO is the Danish version of the International Standard Classification of Occupations (ISCO). This classification changed between 2009 and 2010 from DISCO88 to DISCO08. Information on the crosswalk used is available upon request.

[8] See Appendix B for a detailed list of occupations within each of the categories.

[9] This is consistent with the Statistics Denmark report on Danish subsidiaries abroad in 2016, available at https://www.dst.dk/da/Statistik/nyt/NytHtml?cid=26775.

2.3 Data Selection

After merging the various registers, we end up with a database containing information on more than 90 million workers, around 6.7 million establishments, and 5.2 million firms over a span of 36 years. From these data, we limit our analysis to firms in the private sector. In Denmark, the public sector accounts for around 30-35% of all full-time employees in all municipalities. Further, we restrict the sample to firms in manufacturing, transportation, business services, and finance, insurance and real estate (FIRE). Between 1981 and 2016, these sectors accounted on average for 22.7%, 7.8%, 14%, and 8.5% of total employment in the private sector, respectively. Thereby, we are excluding firms in farming, fishing, raw material extraction, energy/water supply, disposal, construction, wholesale, retail, hotels, restaurants, and culture and leisure.

In order to ensure the quality of our data and results, we further clean the data as follows. First, we drop establishments with no reported location. We also drop those establishments located in Fanø, Læsø, or Christiansø (three small islands with low levels of economic activity). Second, Statistics Denmark includes in the FIRM register all registered firms regardless of their level of activity. Given this definition, we observe around 180,000 firms each year in the whole economy. However, a large share of these firms are quite small, often have irregular activity, and are missing in the accounting records. Therefore, we exclude firms that had fewer than 4 employees for more than 66% of their existence in our database. This restriction is also important in order to avoid shell companies.

Third, in order to drop establishments within firms in which no work was carried out, or which were only part of the firm temporarily, we drop those establishments with 1 or 2 employees and those that only appear in one year.[10] Fourth, to avoid outliers, we drop firms with more than 99 establishments or that exhibit large jumps in the total number of establishments across years. Table A4 presents in detail the number of observations dropped in each step. All of these restrictions lead us to a sample of 688,958 firm-year observations, 871,673 establishments-year observations, and 25,397,415 worker-year observations for the entire period. Alternatively, each year we have on average 19,138 firms, 24,213 establishments, and 705,484 workers (around 42% of the private labor force).

Figure A1 presents various comparisons between all firms in Denmark and those in our sample. Panel B shows that the share of ME firms in our sample is larger than in the whole economy by around 5 to 6.5 percentage points. Nonetheless, the behavior of both shares during this period is quite similar, which suggests that our sample might be capturing the relevant variation. Similarly, the share of employment (Panel C) and production (Panel D) generated by ME firms is larger in our sample than in the whole economy, but their evolution over time has been almost parallel. Table A4 compares workers in our sample with all workers in the private sector. The table shows that the differences between the columns are not substantive. Workers in our sample have slightly higher levels of education, experience, and tenure, which is consistent with their higher hourly wage. In terms of occupations, production and business

[10] These criteria mitigate a potential data-coding problem in 1987, in which we observe an unexplained spike in the number of establishments.

services workers and engineers and scientists are slightly overrepresented in our sample, while managers and clerical workers are underrepresented.

3 The Internal Spatial Organization of Firms

In this section, we present our findings regarding the internal organization of ME firms in Denmark. We present our results as four connected facts that describe the internal geography of firms and changes during the last 26 to 36 years. Most of these facts are, to the best of our knowledge, new to the literature. One contribution of this paper is to show the increasing degree of fragmentation and spatial decentralization within firms. This has largely been theorized in the literature, but has not been shown formally until now.

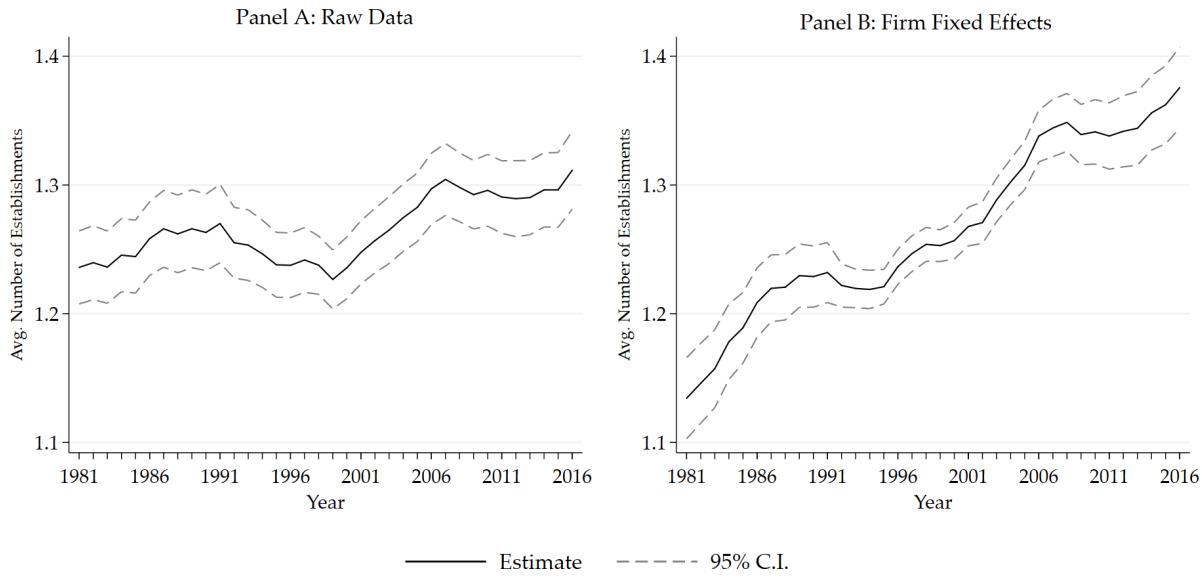
3.1 Firm Fragmentation

In Figures 1 and A1, we showed that the share and number of ME firms in Denmark has been increasing for nearly four decades. These trends should be consistent with an increase in the average number of establishments per firm. We examine this indicator in Panel A from Figure 3, in which we plot the average number of establishments per firm every year. In particular, we plot the estimated year fixed effects from a regression of each firm's number of establishments on year fixed effects. This is equivalent to taking yearly averages, but provides us with confidence intervals. The details of this and all other regressions from the paper can be found in Appendix C, while Table A2 presents their R-squared and number of observations. This plot shows that the average number of establishments per firm in the economy went from 1.24 in 1981 to 1.31 in 2016. This corresponds to a 6.1% increase and is barely significantly different from zero.

The use of raw data to study changes in firm fragmentation can be problematic, since the observed increased in the average number of establishments per firm shown by the raw data can be a combination of within-firm fragmentation and changes in the composition of firms. For instance, the decrease in the average number of establishments observed during Denmark's economic slowdown in the early 1990s could reflect existing ME firms closing establishments or large ME firms exiting the market.

To control for this issue, we run the same regression but include firm fixed effects as well as year fixed effects, and plot the latter in Panel B in Figure 3. This figure shows that after controlling for within-firm variation, the average number of establishments per firm increased from 1.13 to 1.38 during our period, for a 21.3% increase. This change is significantly larger than the 6.1% change observed in Panel A. Since we include firm fixed effects, the identification for this trend comes from firms that either opened and/or closed establishments each year. Therefore, we are capturing within-firm fragmentation and not the selection of different types of firms into or out of the market. Moreover, firm fixed effects control for other variables that do not vary over time at the firm level. When we look only at those firms that have multiple establishments at some point in our period, we observe a more pronounced rise in the number

Figure 3: Evolution of the Average Number of Establishments per Firm



This figure shows the evolution of the average number of establishments per firm. In Panel A, we plot the year fixed effects of a regression of each firm's number of establishments on year fixed effects, which is equivalent to taking the yearly averages. In Panel B, we plot the year fixed effects of a regression of each firm's number of establishments on firm and year fixed effects.

of establishments per firm: from 1.9 to 2.8, which corresponds to a 51% increase (Figure A2).

We summarize our first result as:

FACT 1: *The average number of establishments per firm increased by 21% between 1981 and 2016.*

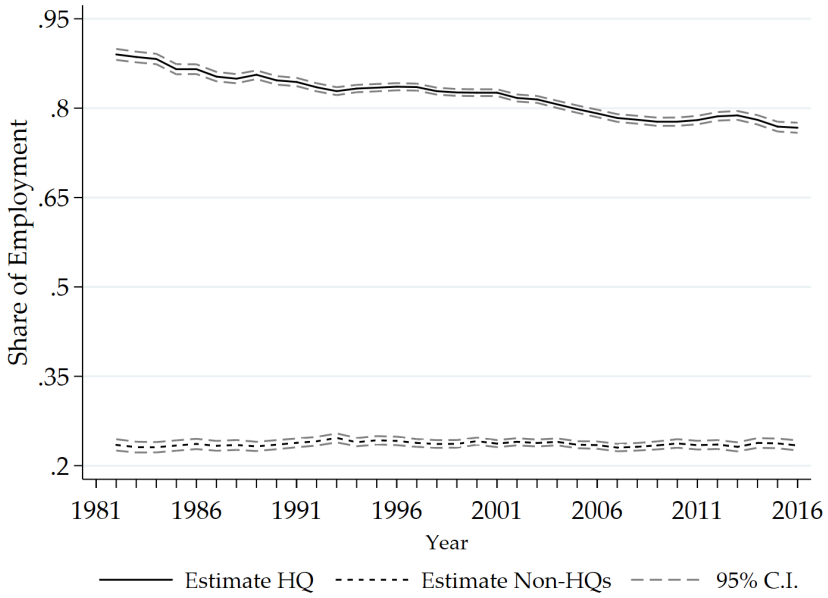
The increase in the number of establishments per firm persists after controlling for the age of the firm; this suggests that is driven not only by the life cycle of firms, as in Bartelme and Ziv (2017). Furthermore, our results also hold if we exclude firms with HQ in the Copenhagen metropolitan area or Aarhus. This implies that increasing competition for land and workers in the main urban centers is not the only force driving firm fragmentation, as suggested by Rossi-Hansberg et al. (2009).

In Figure A3, we examine the change in the number of establishments per firm by sector. The average number of establishments increased in three of the four sectors: business services (from 1.02 to 1.38, or 36%); transportation (from 1.08 to 1.33, or 23%); and manufacturing (from 1.1 to 1.26, or 14%). We also observe an increase in the FIRE sector, although this is much less precisely estimated. Each of these trends might be driven by different factors. First, note that the increase in the number of establishments per firm in the manufacturing sector is happening despite the deindustrialization taking place in Denmark during the last decades (Bernard et al., 2017). Though somewhat puzzling, this upward trend could be explained in part by the expansion of large ME firms. For the business services sector, two factors could explain

this trend. First, the large expansion of business services in the aggregate economy (Eckert, 2019); this sector has seen the largest increase in the total number of firms over this period. Second, firms switching from manufacturing to service sectors, as documented in Bernard et al. (2017).

How we interpret the rise in the number of establishments per firm might change depending on the evolution of the distribution of employment within firms. If the number of establishments increases but the share of employment inside the HQ stays constant, this would mean that firms are mostly fragmenting tasks that were already taking place outside its central offices. However, if the number of establishments increases but the share of employment inside the HQ decreases over time, this would mean that firms are increasingly fragmenting and decentralizing tasks to non-HQ locations. For this reason, we examine the evolution of the average share of workers employed at the HQ and the evolution of the average share of workers across non-HQ establishments. We do this by running regressions of these two variables of firm and year fixed effects and plotting the respective year fixed effects in Figure 4.

Figure 4: Concentration of Employment across Establishments



This figure shows the estimated year fixed effects from regressions of each firm's average share of workers employed at the HQ and the average share of workers across non-HQ establishments on year and firm fixed effects. For this figure, we only use firms that had multiple establishments at some point between 1981 and 2016.

The solid line in Figure 4 shows that the increase in the average number of establishments has been accompanied by a decrease in the share of workers employed at the firm's HQ; specifically, the share of employment at HQ went from 89% to 76%. Even though a reduction of 13 percentage points might seem small, recall that firms with multiple establishments are usually large firms, and even a small reduction in this share means that a considerable amount of jobs are being reallocated. In addition, notice that the average share of employment across non-HQ

establishments (dotted line) has remained constant—around 23%—over this period.[11] These results suggest that firms are increasingly decentralizing activities from the HQ to other locations. Together with the result from Figure 3, they also suggest that firms are decentralizing these HQ activities to new non-HQ establishments, instead of increasing the relative importance of existing non-HQ establishments.

3.2 Spatial Decentralization

Location is probably one of the first and most important decisions a firm makes before opening a new establishment. When choosing a new location, firms must balance the higher communication and monitoring costs associated with longer distances with the gains from exploiting local comparative advantages far from the HQ. Therefore, we investigate how establishment location and spatial decentralization within firms has evolved over time. We start by examining the evolution of the average distance between a firm's establishments and its HQ given by the aggregate data. We present this trend in the left plot in Panel A in Figure 5. The figure shows a sustained increase in the average distance between establishments and their HQ from 8 km in 1981 to 12 km in 2016 (50%).

Even if the average distance between establishments and their HQ increased over time, it does not necessarily mean that firms became more spatially decentralized. For instance, it could be that more dispersed firms are only placing a few workers in far-away establishments and keeping most of the labor force near the HQ. Therefore, we also consider the evolution of the average distance of workers from their HQ by computing the weighted average of the distance of establishments from their HQ, where weights are given by the share of workers in each of the firm's establishments. The right graph in Panel A in Figure 5 shows a 47% increase in the average distance between workers and their HQ, from 5.9 km in 1981 to 8.7 km in 2016.

Similar to what we argue above, using raw data to study changes in the spatial decentralization of firms can be misleading, since the observed increased in the average distance between establishments and their HQ can be a combination of within-firm decentralization and changes in the composition of firms (i.e., spread-out firms entering the market or compact firms exiting). In order to capture the spatial decentralization happening within firms, we run a regression of each firm's average distance between its establishments and HQ on year and firm fixed effects. The left graph in Panel B in Figure 5 plots the year fixed effects of this regression. This figure shows a sustained increase of 108% in the average distance between a firm's establishments and its HQ, relative to the 1981 mean of 6.5 km.

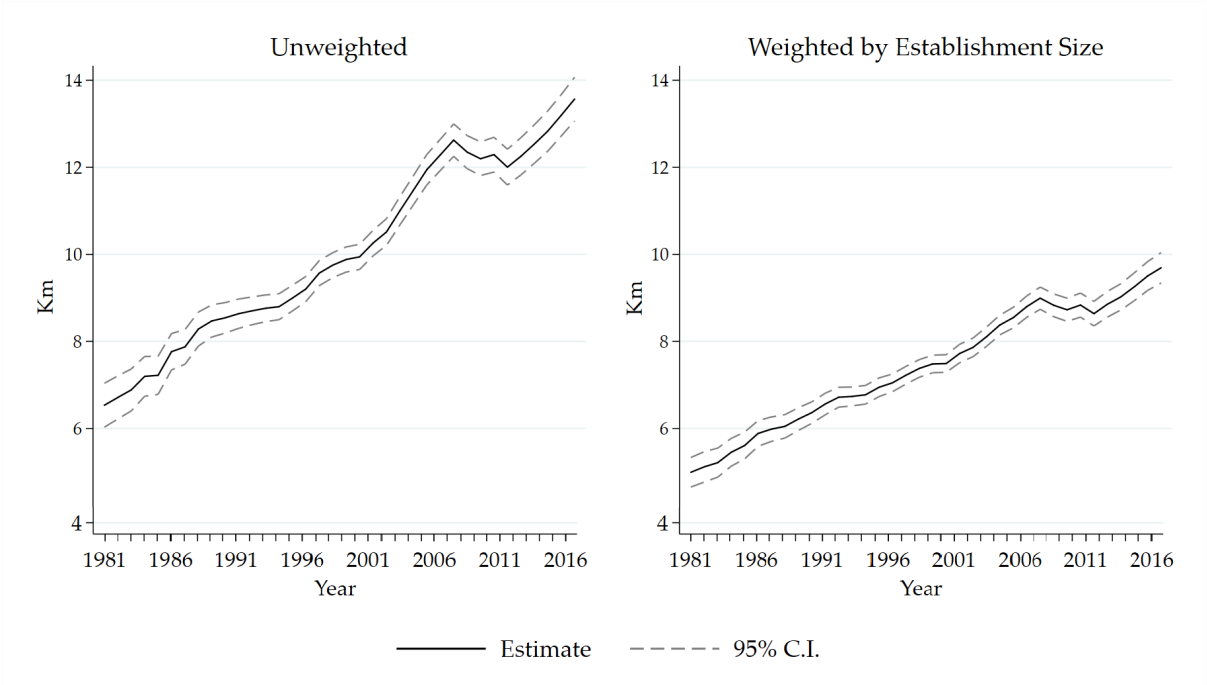
Note that once we include firm fixed effects in this regression, both the level and percentage change in the average distance to HQ are larger compared with the averages using raw data (Panel A). In other words, looking only at the aggregate data underestimates the true degree of spatial decentralization within firms. We identify two possible reasons for this difference. First,

[11] In Figure A4, we also explore the evolution of the average establishment size. This figure shows that on average, firms and all types of establishments in Denmark (SE firms and the HQ and non-HQ establishments of ME firms) became larger over our sample period.

Figure 5: Average Distance between Establishments and Headquarters

Panel A: Raw Data

Panel B: Within Firm Regressions



This figure shows the evolution of the average distance of establishments from their headquarters. In Panel A, we plot the year fixed effects of a regression of each firm's average distance on year fixed effects, which is equivalent to taking yearly averages. In Panel B, we plot the year fixed effects of a regression of each firm's average distance on firm and year fixed effects. For figures in the left panel, we use unweighted averages; for figures in the right, we use weighted averages using the share of workers in the establishment as weights.

most firms that enter the market are single-establishment (SE) firms (85%). Second, new firms are more compact, with an average distance to HQ that is 66% lower than in existing firms.

We also run within-firm regressions using the average travel time between establishments and their HQ as the dependent variable. The left plot in Figure 6 shows a trend and results similar to those using the average distance. In particular, average travel time increased from 10.4 minutes in 1981 to 15.4 minutes in 2016, which is a 48% increase. This lower growth rate may be due to the fact that traveling between municipalities is usually via highways or trains with higher speed limits and less congestion than shorter journeys within metropolitan areas.

Figure 6: Average Travel Time between Establishments and Headquarters

This figure shows the estimated year fixed effects from a regression of each firm's average travel time between its establishments and headquarters on year and firm fixed effects. In the left panel, we use unweighted averages, and in the right panel we weight by the total number of workers in the establishment.

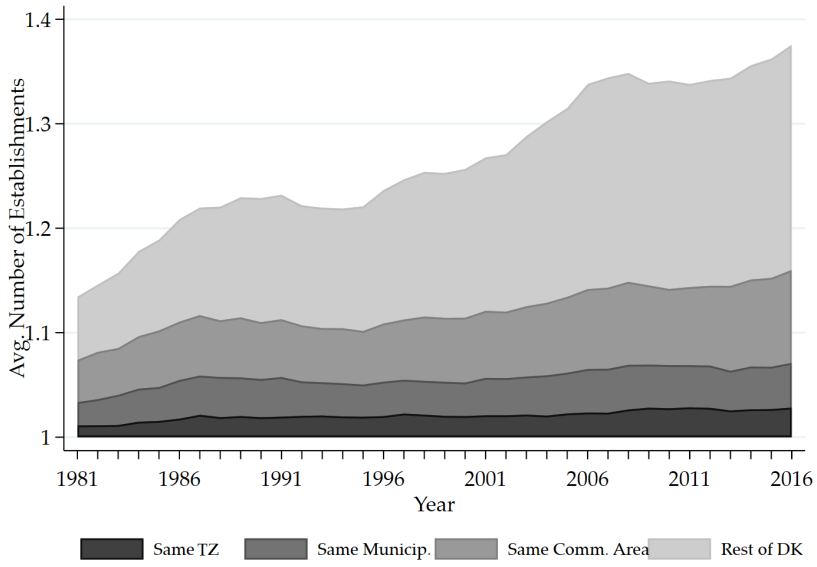
The identification of changes in the average distance of establishments from their HQ comes from firms that opened and/or closed establishments. However, given the high fixed costs entailed by these actions, a firm could still decentralize some jobs without opening new workplaces. To examine this idea, we run the regressions using the average distance and travel time of workers to their HQ as dependent variables.[12] The right plot in Panel B of Figure 5 shows the estimated year fixed effects when we use the average distance. The change is lower in this case: a 94% increase relative to the 1981 value of 5 km. This increase indicates that even if a firm does not open new establishments, it could be reallocating some of its jobs out of the HQ. When we use travel time (right plot from Figure 6), the results show an increase from

[12]This regression also helps us control for possible changes in the way Statistics Denmark defines establishments. Nevertheless, we are not aware of any relevant change in these definitions that might affect our results.

9.3 to 12.7 minutes (36%). Finally, we also run these regressions using only those firms that had multiple establishments at some point in our period. In this case, Figure A6 shows that the average distance of establishments and workers from their HQ increased from 24 to 51 km (111%) and from 15 to 33 km (124%), respectively.

The magnitude of these changes could mean that a lot of the expansion within firms takes place within commuting zones, in line with recent evidence for US firms in Bartelme and Ziv (2017). To explore this possibility, we decompose the evolution of the total number of establishments per firm—presented in Figure 3—between new establishments in the same traffic zone (TZ) as their HQ, in the same municipality (excluding the HQ TZ), in the same commuting area (excluding the HQ municipality), and the rest of the country. Figure 7 presents the results of this decomposition, two of which we highlight. First, there have been increases in the average number of establishments in the same traffic zone, same municipality, and same commuting area as the firm's HQ, each accounting for 7%, 12%, and 19% of the total change, respectively. Second, these changes are small compared with the change in the number of establishments outside the HQ's commuting area: 62% of the total change.[13]

Figure 7: Decomposition of the Total Number of Establishments



This figure shows the evolution of the total number of establishments from a regression of each firm's total number of establishments on year and firm fixed effects, separating those establishments located in the same traffic zone (TZ) as their HQ, same municipality, same commuting area, and the rest of the country.

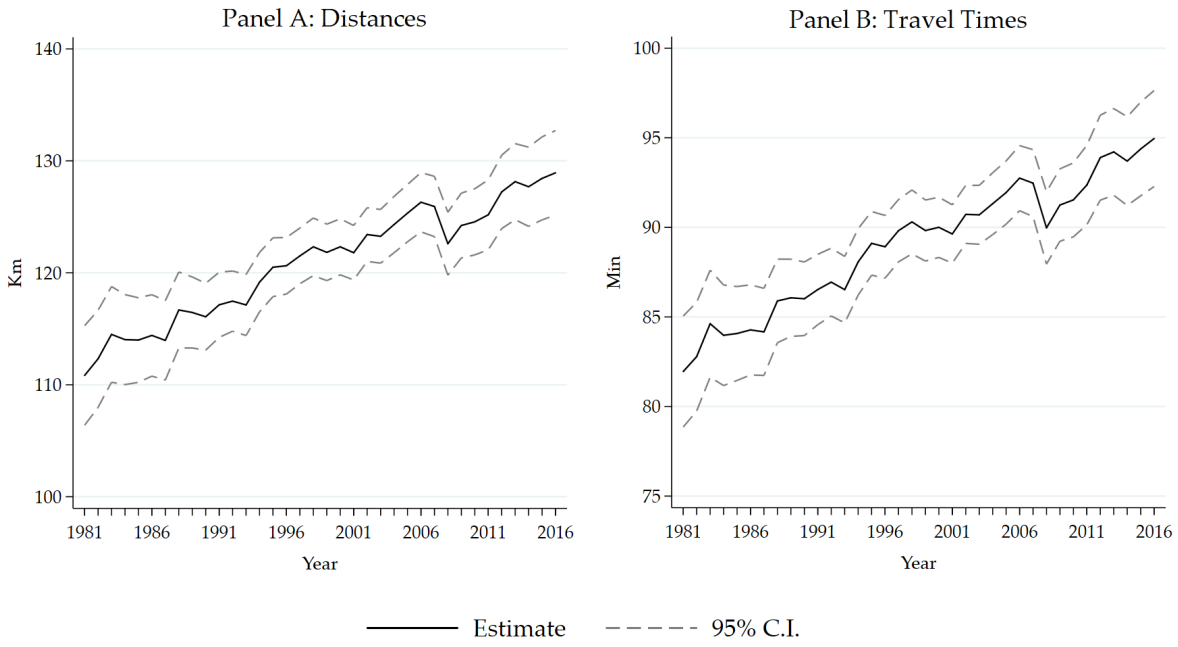
These results lead to our second fact:

FACT 2: *The average distance between establishments and their HQ doubled during the last 36 years. These changes are mainly driven by the creation of establishments outside the HQ's commuting area.*

[13]Panel B in Figure A2 presents the results of the decomposition using only those firms that had multiple establishments at some point during our period. These results are almost equivalent.

The measures of distance and travel time used in the previous figures include the distance and travel times of the firm's HQ to itself. Since our regressions show changes within firms, if we excluded the HQ from these measures, we would exclude firms that go from one to multiple establishments. In other words, if we exclude these zeros, we would only capture the decentralization taking place in firms that are already decentralized (i.e., that already have multiple establishment). On the other hand, by including the HQ, our measures are include zeroes; thus the baseline distances of our figures are smaller, which increases the percentage changes. To reconcile these points, in Figure 8 we present the results of the (unweighted) regressions, but exclude the distance (or travel time) of the HQ to itself. In both cases, the levels of the changes are larger, but the growth rates are smaller. First, the average distance of the establishments to their HQ increased by 18 km, which corresponds to an increase of 16.3% relative to the 1981 mean of 111 km. Second, the average travel time increased by 13 minutes, which corresponds to an increase of 15.9% relative to the 1981 mean of 82 minutes. These figures also show that firms that already have multiple establishments are considerably more dispersed, since the average distance between establishments and their HQ is fairly large.

Figure 8: Measures of Spatial Decentralization - Excluding Headquarters



This figure shows the estimated year fixed effects from a regression of each firm's average distance (Panel A) or average travel time (Panel B) between its establishments and HQ on year and firm fixed effects. The dependent variables exclude the distance or travel time of the firm's HQ to itself. Averages are unweighted in both panels.

Average distance to the HQ is influenced equally by establishments close to and far from the HQ. For example, if a firm has a satellite establishment 40 km from the HQ and opens a third 8 km from the HQ, our measure of average distance would go from 20 to 16 km. In this case, there would be an increase in firm fragmentation (more establishments), but a decrease in spatial decentralization (less average distance). Therefore, as a robustness check, we look at

the evolution of the distance to the establishment farthest from the HQ. Figure A7 shows that the average maximum distance to HQ increased from 9.8 to 24.4 km (a 148% increase), and from 47 to 103 km (119%) when we only consider firms that had multiple establishments.

We also examine the changes in our four aggregate sectors in Figures A8 and A9. With the exception of the FIRE sector, all sectors experienced an increase in the average distance between establishments and HQ: business services by 13.2 km (an increase of 427%), transportation by 8.7 km (155%), and manufacturing by 4 km (61%). The relatively small increase in the manufacturing sector is consistent with the fact that this sector faces higher fixed and fragmentation costs (communication and shipping). When we weight by the size of the establishment, we see an increase of 3 km for manufacturing (54%), 5.8 km for transportation (121%), and 8.2 km for business services (307%). The non significant changes in the FIRE sector are potentially explained by both high within-firm agglomeration forces and the outsourcing of some activities to other companies.

3.3 Functional Specialization

So far, we have shown that firms are becoming more fragmented and spatially decentralized. In this subsection, we examine how this decentralization has affected workers in different occupations and whether it has been a general phenomenon for all types of workers. We start by investigating the evolution of the average distance to the HQ for workers in each occupational group. We do this by estimating similar within-firm regressions as the ones described in Fact 2 (i.e., Figure 5), but in which the weights are defined for each occupation separately. We plot the year fixed effects of these regressions in Figure 9. These figures start in 1991, which is the first year for which we have data on occupational classification.

Figure 9 shows that all occupations experienced a similar percentage change in their average distance to HQ of around 70%. However, when we examine the estimates closely, a ranking of occupations with respect to changes in their distance to the HQ appears. First, workers in business services, and engineering and science occupations experienced an increase of around 3.55 km. Second, production workers experienced an increase of approximately 3 km. Third, the distance for managers and clerical workers increased by 2.75 km. Therefore, our results suggest that firms are currently locating managers and clerical workers relatively close to their HQ, followed by workers in production, business services, and engineering and sciences occupations. The results are fairly similar when we look at changes in travel times.

In Figure A10, we examine these changes when we exclude the distance of the HQ to itself from our measures. In this case, workers in managerial, business services, and engineering occupations experienced a larger increase in their distance to HQ compared with production and clerical occupations. Instead of contradicting the results from Figure 9, these figures suggest two complementary phenomena. First, without taking into account workers at the HQ, firms are increasingly locating high-skilled workers in establishments seemingly far from the HQ and, probably, closer to other locations in which they can exploit comparative advantages (e.g., larger

Figure 9: Average Distance to the HQ by Occupation

This figure shows the estimated year fixed effects of a regression of each firm's average distance of establishments to the HQ (weighted by the establishment's relative number of employees within each occupation category) on year and firm fixed effects.

cities, universities, transportation hubs, etc.). Second, even though production and clerical occupations are far from the HQ (between 120 km and 130 km from the HQ), ME firms are not moving these activities to much farther locations within the country.

We can also study the evolution of the share of firm's employment at HQ for each of the occupational categories. Figure A11 shows these changes. In this case, lower-skilled occupational groups experienced the largest decrease: 8 and 6.7 percentage points for production and clerical workers, respectively. On the other hand, the decrease for high-skilled occupations is less sharp: 6, 4.9, and 3.9 percentage points for workers in business services, engineering and sciences, and managerial occupations.

All of these results point the existence of strong within-firm agglomeration economies. Specifically, firms could obtain productivity gains by putting workers in particular occupations together. For example, by concentrating managers at the HQ, or by locating workers in business services and engineering occupations close to each other, because this could lead to an increase in knowledge spillovers. Decreases in communication costs that resulted from the broadband expansion in the first half of the 2000s potentially contributed to these patterns. If communication between establishments is relatively easier, firms can afford to locate some occupations farther from the HQ, and retain occupations that benefit the most from agglomeration economies and face-to-face communication, such as managers, at the HQ (Storper and Venables, 2004).

In order to study how these two sets of results are related, we study the contribution of each occupation to the changes in Figure 5. For this purpose, we express firm f's average distance of workers to the HQ at time t ($\bar{D}_{HQ,t}$) as a weighted sum of the average distance for each occupation o, $\bar{Dist}^o_{ft}$:

$$\bar{D}_{HQ,t} = \sum_o \left(\frac{L_{of}}{L_f}\right)_t \bar{Dist}^o_{ft} = \sum_o \left(\frac{L_{of}}{L_f}\right)_t \left[\sum_j dist_j \left(\frac{L_{oj}}{L_{of}}\right)_t\right], \tag{1}$$

where $\left(\frac{L_{of}}{L_f}\right)_t$ is the share of workers in occupation o within firm f at time t, and $\left(\frac{L_{oj}}{L_{of}}\right)_t$ the share of workers in occupation o at establishment j relative to the total amount of workers in that same occupation inside firm f at time t. Using equation (1), we investigate the contribution of each occupational category to the change in the average distance of workers to the HQ. We also decompose this contribution into (i) the change in the average distance of each group of workers and (ii) the change in the relative use of occupation o inside the firm, separating by their use at the HQ, at establishments relatively close to the HQ and at establishments relatively far from the HQ. We show the results in Table 1, where we define close-by establishments as those non-HQ establishments located in the same commuting area as their HQ. Technical details of the decomposition can be found in Appendix C.

The decomposition shows that workers in business services, engineering and sciences, and production occupations contribute by 33.5%, 29%, and 27% to the overall change in the average distance of workers to their HQ, respectively. Clerical workers contribute by 6.81% to this

Table 1: Changes in Average Distance of Workers to HQ, 1991-2016

Value 1991	**Value 2016**	**Change**
6.43 km	9.40 km	46.07%
Managers		9.81%
Change in Distance		4.02%
Change in Use		5.79%
Change in Use HQ		5.43%
Change in Use Close Est		0.10%
Change in Use Far Est		0.26%
Production		27.03%
Change in Distance		28.01%
Change in Use		-0.98%
Change in Use HQ		-3.13%
Change in Use Close Est		0.78%
Change in Use Far Est		1.37%
Business Services		33.54%
Change in Distance		16.84%
Change in Use		16.70%
Change in Use HQ		14.02%
Change in Use Close Est		0.95%
Change in Use Far Est		1.73%
Engineers & Scientists		29.12%
Change in Distance		24.33%
Change in Use		4.78%
Change in Use HQ		3.03%
Change in Use Close Est		0.12%
Change in Use Far Est		1.63%
Clerical		6.81%
Change in Distance		16.19%
Change in Use		-9.38%
Change in Use HQ		-10.02%
Change in Use Close Est		0.15%
Change in Use Far Est		0.49%
Others		-6.31%
Change in Distance		2.44%
Change in Use		-8.74%
Change in Use HQ		-8.58%
Change in Use Close Est		-0.16%
Change in Use Far Est		-0.01%

This table shows the decomposition of the total change in the distance of firm's workers to their HQ into changes in the use and the average distance of six occupational categories. The percentages add up to 100% and not to the total change (88.07%). Changes in the use of each occupation are further decomposed into changes in their use at HQ establishments, establishments within the HQ commuting zone (close), and establishments outside the HQ commuting zone (far). This decomposition is described in Equation (1).

change, and managers by around 10%. Further decomposing each occupation's contribution into their changes in relative use and changes in average distance to HQ, we observe that the contribution of each occupation comes from different sources. For managers, 60% of their contribution comes from an increase in their use at the firm level, particularly inside the firm's HQ. In fact, between 1991 and 2016, managers went from being 4.9% of the total number of workers within firms to being around 6.2%.

For clerical workers, we observe two strong opposing forces. On one hand, the decentralization of these occupations contributes 16.2% to the total. On the other hand, there has been a reduction in the use of these occupations that contributes negatively to the total change, by 9.4%; this reduction mainly comes from a reduction in clerical workers at the HQ. Furthermore, we observe that increases in the distance of production workers from the HQ contribute by around 28% of the observed total change. The table also shows a movement of production jobs from the HQ to non-HQ establishments. These movements are consistent with the observed patterns in Figures 9 and A11.

For engineers and workers in the science professions, most of their contribution comes from changes in their average distance to the HQ: one-fourth of the total. Increases in the average distance of engineers and scientists to their HQ happened in two waves: the first at the beginning of the 2000s and the second starting around 2011, coinciding with recent expansions in the tech and communications sectors. Firms also increased their use of these occupations at HQ locations and in locations relatively farther away. These facts are consistent with firms' desire to locate these jobs inside the HQ or in municipalities with a relatively high concentration of universities, research centers, and workers in the science professions, even if they are far from the HQ.

Lastly, changes in the location of workers in the business services occupations contribute one-third of the total change in the average distance of workers to the HQ. For workers in these professions, the increase in their use within firms—especially inside HQ establishments—is just as important as the increase in their average distance to the HQ. Two possible reasons are behind these changes. On one hand, business services firms and business services workers have become more important in recent decades. On the other hand, this has probably caused more competition for office space and workers, thereby promoting the relocation of business services workers to other municipalities for cost-saving reasons, as argued by Liao (2012). This relocation has gotten easier due to improvements in communications technology.

Based on these findings, we formulate a third fact:

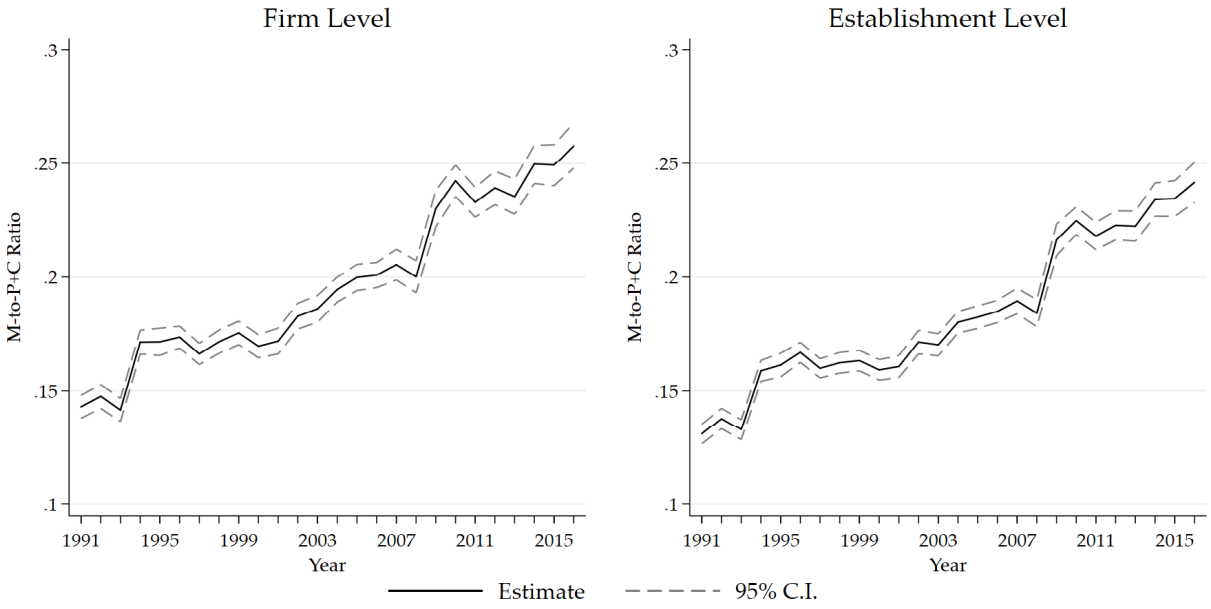
FACT 3: *The spatial decentralization of firms is mainly driven by an increase in the average distances of production workers, and engineers and scientists to the HQ, an increase in the use and distance of business services workers, and a decrease in the use of clerical workers.*

3.4 Reduction in the Span of Control

In the previous decomposition, we found important changes in the use of managers, production and clerical workers within firms and in their location across establishments between 1991 and 2016. These trends imply that the ratio of managers to production and clerical workers might have changed during the same period, both within firms and within establishments. The evolution of this ratio is important, because it reflects changes in the span of control and the size of production teams within organizations and workplaces (Lucas, 1978; Garicano and Rossi-Hansberg, 2006).

We start by computing the ratio of managers to production and clerical workers for each firm and regress it on firm and year fixed effects. The left graph in Figure 10 shows the estimated year fixed effects. The figure shows a clear upward trend of this ratio, going from approximately 1 manager for every 7 production/clerical workers to around 1 manager for every 3.9 workers in 2016. In other words, there has been a systematic reduction in the size of the average production team within firms or, equivalently, the span of control within firms decreased by 46%. The results are fairly similar when we examine this ratio at the establishment level. Specifically, the right graph in Figure 10 shows that in the average establishment, this ratio went from approximately 1 manager for every 7.6 production/clerical workers to around 1 manager for every 4.1 workers in 2016, for a decrease of 45%.

Figure 10: Managers to Production and Clerical Workers

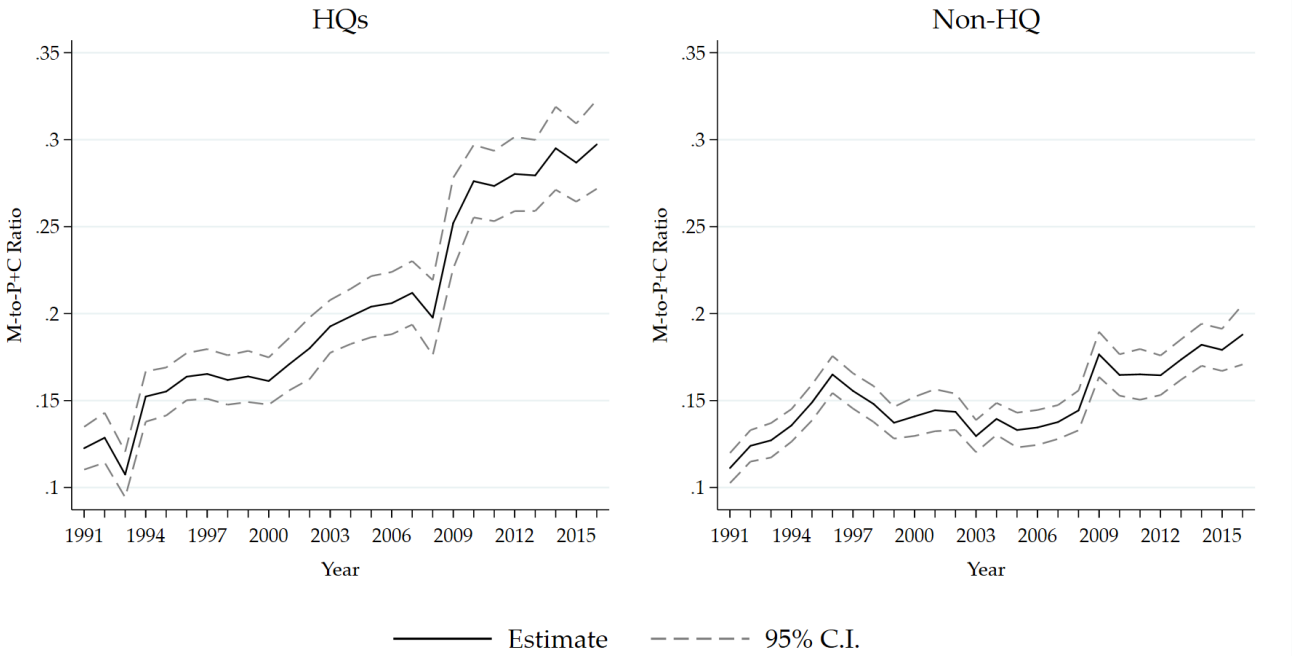


This figure shows the estimated year fixed effects from a regression of each firm's (Panel A) or establishment's (Panel B) ratio of managers to production and clerical workers, on year and firm fixed effects (Panel A) or on year and establishment fixed effects (Panel B). In both regressions, we include all the establishments and firms in our sample.

The reduction in the manager-to-worker ratio could come from different establishments within firms. We examine the differences across two related characteristics: HQ and non-HQ

status and city size. For the first case, we run a establishment-level regression of the manager-to-worker ratio that includes establishment fixed effects and an interaction between a HQ dummy variable and year fixed effects. We present the results in Figure 11, where we plot the estimated year fixed effects of the regression, separating between HQ and non-HQ establishments. Both graphs show that the managerial ratio was quite similar in 1991 and has increased for both types of establishments. However, the increase has been much larger for HQ establishments: 143% compared to 69% for non-HQ establishments. Equivalently, HQ had on average 1 manager per 8.2 workers in 1991 and 1 manager per 3.4 workers in 2016 (a 59% decrease), while non-HQ establishments had on average 1 manager per 9 workers in 1991 and 1 manager per 5.3 workers in 2016 (a 41% decrease).

Figure 11: Managers to Production and Clerical Workers
HQ vs. non HQ Establishments

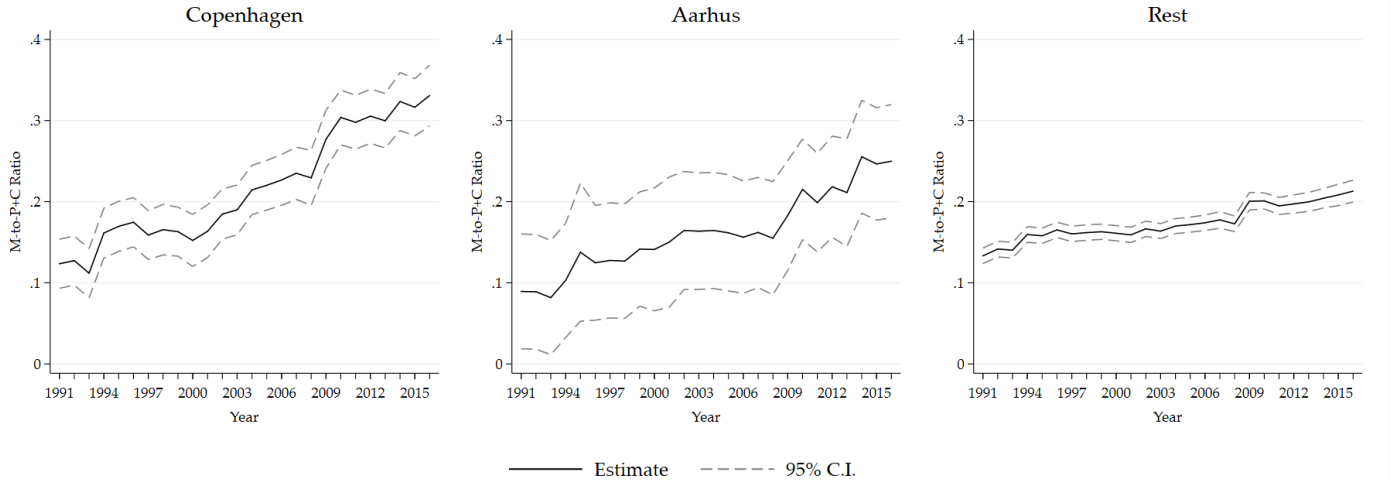


This figure shows the estimated year fixed effects of a regression of each establishment's ratio of managers to production and clerical workers on firm and year times HQ fixed effects, where HQ is a dummy variable that indicates whether an establishment is a HQ or not.

Regarding establishment location, Figure 12 shows that the increase in the managers-to-workers ratio observed at the firm level comes mainly from establishments located in the two most populated urban areas: Copenhagen and Aarhus. More specifically, we observe an increase of 181%, 169%, and 60% of this ratio for establishments located in Copenhagen, Aarhus, and the rest of the country, respectively. These changes correspond to a decrease in the span of control within establishments of around 64% for both cities and 38% for the rest of the country. We confirm this result by running a regression of the ratio of managers to production and clerical workers on year and establishment fixed effects and an interaction between the year fixed effects and the log size of the municipality where the establishment is located. Figure A13 shows an increase in the correlation between this ratio and the size of the municipality from zero in 1991 to

around 0.035 in 2016. This increase is consistent with Figure 12 and suggests that production teams within establishments are becoming smaller in more populated municipalities.[14] This result is in line with recent evidence for the US presented by Santamaria (2019), who argues that the rise in the complexity of the production process in big cities is behind these changes.

Figure 12: Managers to Production and Clerical Workers by Municipality



This figure shows the estimated year times area fixed effects of a regression of each establishment's ratio of managers to production and clerical workers on firm and year times area fixed effects, where area includes three categories: Copenhagen metropolitan area, Aarhus, and the rest of the country.

In Figure A12, we present the evolution of the ratio of managers to production and clerical workers within firms and within establishments (for all and by HQ status) using the raw data. The 1991 baseline and the evolution of this indicator are similar to the ones above, but the reduction in the span of control within units is larger. This difference could suggest that new establishments (either new SE firms or from existing ME firms) have lower span of control or relatively few workers per manager.

We summarize these findings in our fourth fact:

FACT 4: *The span of control within firms has decreased by 45% over the last 26 years. This change is driven by an increase in the ratio of managers to production and clerical workers within HQ establishments and establishments located in the largest cities.*

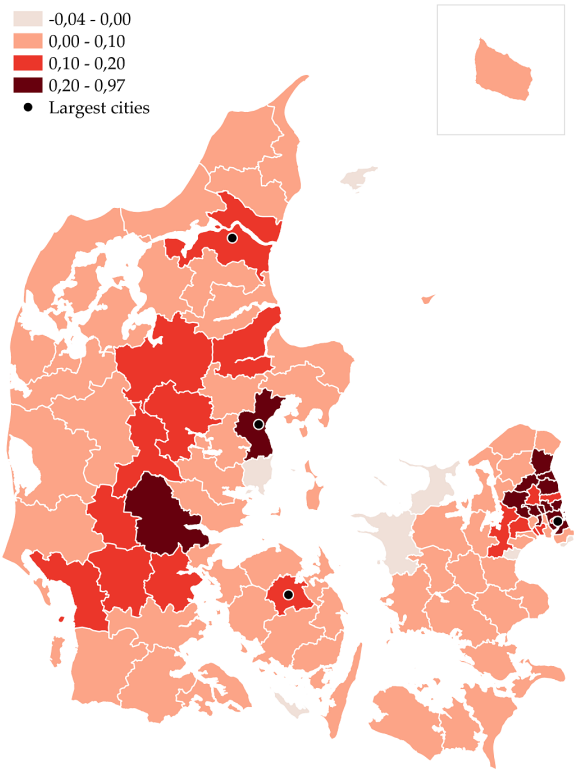
Our results partially explain the evolution of the aggregate specialization patterns that Duranton and Puga (2005) describe for the US. In particular, they argue that increasing firm fragmentation could be leading to a decrease in sectoral specialization across US cities, and to an increase in functional specialization, measured as the relative concentration of managers to production workers in large cities. In order to briefly examine this hypothesis, we compute the change in the average ratio of managers to production and clerical workers across establishments for each municipality between 1991 and 2016. Figure 13 shows that this ratio increased during this period for 91 out of the 98 municipalities in the country. Figure A14 shows the levels of this

[14] This correlation suggests that when comparing a municipality with one three times larger, the larger municipality will tend to have establishments with an average manager-to-worker ratio 0.1 points larger.

ratio for 1991 and 2016 separately. These two figures show that at the beginning of the 1990s, municipalities were not too different in terms of this measure, but since then it has increased substantially for Copenhagen, its metropolitan area, and the other main urban areas.

Figure 13: Managers to Production and Clerical Workers Ratio by Municipality

Changes between 1991 and 2016



This figure shows the percentage-point difference between 1991 and 2016 of the average ratio of managers to production and clerical workers across establishments for each municipality. The 98 municipalities are divided into quartiles according to the changes in this ratio. Black dots mark Copenhagen, Aarhus, Aalborg, and Odense.

Furthermore, we decompose these changes into changes in the ratio within SE firms, within establishments belonging to ME firms, entry of establishments (either SE or belonging to ME firms), and exit of establishments. For the whole country, we find that 71% of the nationwide increase in the average ratio of managers to production and clerical workers was driven by increases in the average ratio within ME firms, while increases in the average ratio within SE firms explained 36% of the total increase.[15] At the municipality level, we find that increases in the average ratio within ME firms is the main contributor to the growth in the average ratio of managers to production and clerical workers in 35 out of 98 municipalities. Moreover, the opening of establishments belonging to ME firms is the main contributor in 15 municipalities. Therefore, in more than half of the country's municipalities, the reduction in the span of control is driven by the growth of the managers-to-workers ratio in ME firms or by the fragmentation of these firms. This share is even larger in the capital region (*Hovedstaden*), with 19 out of 32 municipalities (60%).

[15]Changes in the composition of firms and net entry explain -4.6% and -2.3%, respectively.

4 Conclusions

This paper studies the internal spatial organization of firms and its evolution over nearly four decades. Consistent with intuition, we find that firms have become more spatially dispersed and their geographic span of control broader. However, this fragmentation is not universal across the firm's activities. Instead, firms are spatially fragmenting by functions. In particular, we see an increasing concentration of managerial activities around firms' central offices.

Using detailed administrative data covering the universe of firms, establishments, and workers between 1981 and 2016 in Denmark we document four stylized facts. First, we show that the average number of establishments within firms increased by 21% between 1981 and 2016. Second, the average distance between establishments and workers to their headquarters (HQ) doubled during this period. This fact suggests that firms are placing both establishments and workers farther from their HQ, and particularly outside their labor market areas. Third, we show that this spatial decentralization is driven by increases in the average distance of workers in production, and engineering and sciences occupations; an increase in the use and distance of business services workers; and a decrease in the use of clerical workers, particularly at HQ. Fourth, we show that the ratio of managers to production and clerical workers within firms has increased, going from approximately 1 manager for every 7 workers to 1 manager every 3.9 workers. This 45% decrease in the average team size within firms has been driven by a particularly large increase in this ratio inside HQ establishments and establishments located in the largest cities.

These results have important implications for research on agglomeration and urban economics. As our facts suggest, the world seems to be moving from a regime with mostly SE firms to a regime in which ME firms are increasingly important. These firms are likely to locate their manager-intensive HQ in larger cities and production and clerical tasks in smaller cities. Therefore, our evidence is consistent with firm fragmentation's partially explaining the shift toward functional specialization, as suggested by Duranton and Puga (2005). Moreover, our results imply that cities that retain HQs will be increasingly dominated by high-skilled, high-paid workers, which has clear implications for economic inequality, housing affordability, and the operation of regional and national labor markets.

In addition, our results have implications for research on organizational economics. For instance, most of the recent literature on the theory of the firm considers agency problems to be the main mechanisms affecting the organization of firms (Aghion and Holden, 2011). However, this literature almost never considers how space and distance affecting activities such as monitoring and coordination, which are critical in the design of incentive contracts. As this paper shows, the share of multi-establishment firms and the degree of spatial decentralization of workers within firms has been increasing over the last four decades. Since these trends will probably continue, space will play an increasingly important role in the organization of workers and activities within firms. Consequently, ignoring this factor would cause research on the internal structure of organizations and the design of contracts to be incomplete.

The results from this paper also motivate future research on the causes of spatial allocation of resources within firms. Several forces could be behind the facts documented in this paper. First, fragmentation costs are important, since the movement of knowledge, people, and goods is fundamental for different operations within firms. As these costs decrease, it becomes easier for geographically compact firms to locate some activities farther from the HQ. Second, comparative advantages and high labor and land costs in certain locations might generate incentives for fragmentation that lower marginal costs. Moreover, when facing higher costs in a location, firms could choose to leave tasks that benefit the most from the location's agglomeration economies. We study these mechanisms in Acosta and Lyngemark (2020).

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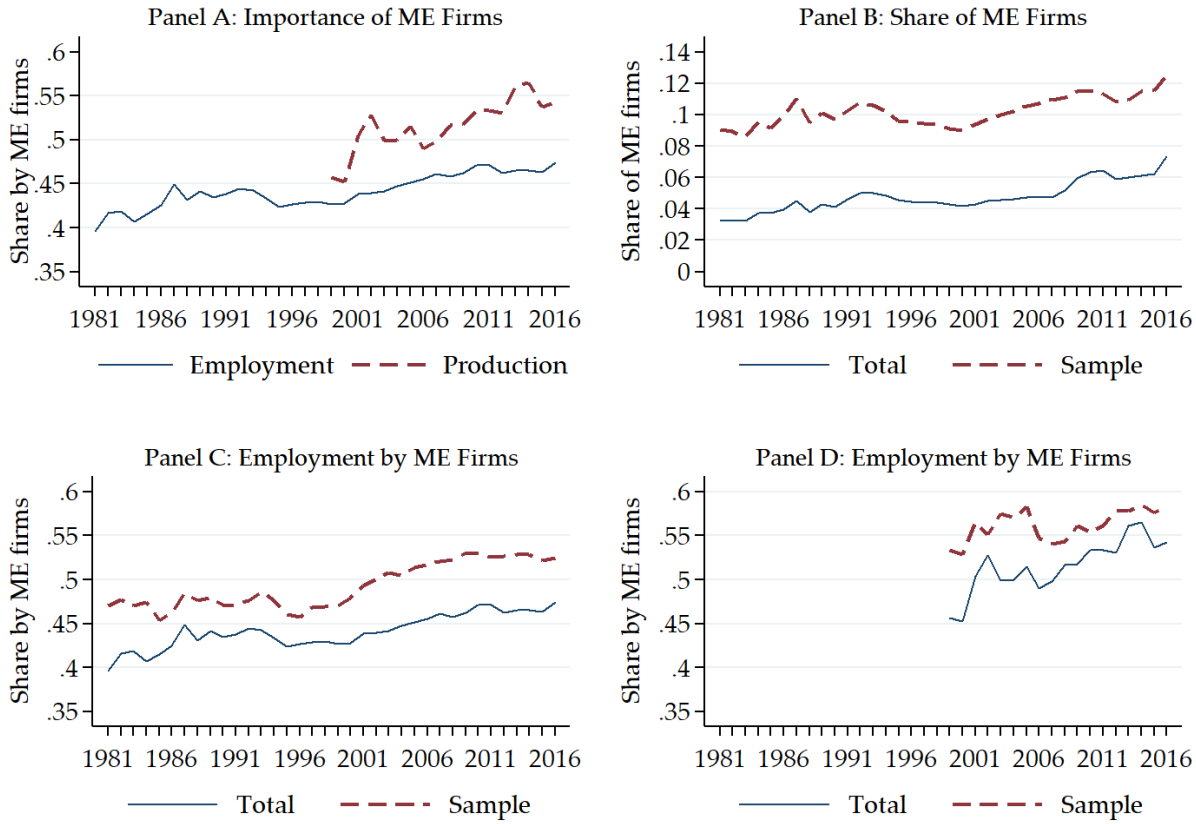
A Extra Tables and Figures

Figure A1: Multi-establishment Firms in Denmark



Panel A of this figure shows the evolution of the share of employment (solid line) and production (dashed line) generated by multi-establishment firms in Denmark between 1981 and 2016. Panel B shows the share of multi-establishment firms both in all of Denmark (solid line) and in our sample (dashed line). Panel C shows the share of employment generated by multi-establishment firms both in all of Denmark (solid line) and in our sample (dashed line). Panel D shows the share of production generated by multi-establishment firms both in all of Denmark (solid line) and in our sample (dashed line). The value of production is only available for most firms starting in 1999.

Table A1: Worker Characteristics: Total Private Sector vs. Sample

Variable	Total Private Sector	Sample
N	59,962,803	25,391,415
Age	37.71	38.96
Female	35.97%	34.34%
Danish	94.07%	93.72%
Region		
Copenhagen Metro	33.76%	34.22%
Rest of Zealand / Bornholm	11.84%	10.03%
Funen	7.86%	7.49%
South / East Jutland	27.93%	28.64%
North / West Jutland	18.61%	19.62%
Education		
Primary & secondary	42.66%	39.37%
Vocational training	39.06%	37.21%
Short and medium cycle	10.94%	13.96%
Long cycle	4.56%	6.74%
Labor Market		
Hourly wage	218.19	236.07
Experience	13.09	14.62
Tenure	3.92	4.48
Occupation		
Manager	5.04%	4.81%
Production	32.48%	38.26%
Business Services	11.40%	13.80%
Clerical	27.82%	18.87%
Engineer / Scientists	9.48%	14.68%
Other	13.78%	9.59%

This table shows the descriptive statistics for all workers in Denmark between 1981 and 2016 who work in the private sector (column 2) and who appear in our sample (column 3), which is described in Section 2

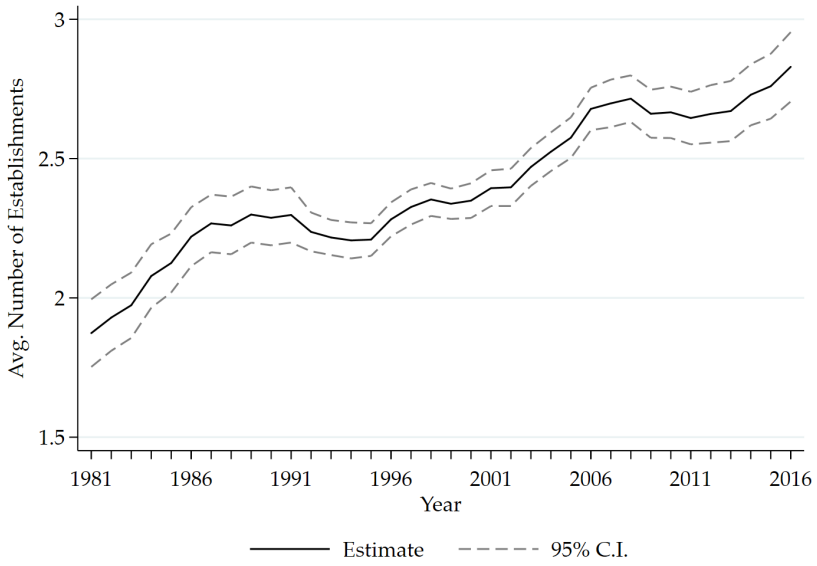
Table A2: Relevant Regressions Statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
						Total Establishments						
	All		ME Firms		Same TZ		Same Municipality		Same Commuting Area		Rest of the Country	
N	688,958	688,958	130,292	130,292	688,958	688,958	688,958	688,958	688,958	688,958	688,958	688,958
R2	0.000	0.002	0.001	0.009	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.002
Firm FE	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Firms		70,736		9,174		70,736		70,736		70,736		70,736
Figure	3	3		A2		7		7		7		7
	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
	Average Distance to HQ				**Average Travel Time to HQ**				**Average Distance to HQ - Excluding HQ**			
	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
N	688,958	688,958	688,958	688,958	688,958	688,958	688,958	688,958	61,303	61,303	61,303	61,303
R2	0.002	0.001	0.005	0.005	0.001	0.001	0.006	0.005	0.015	0.016	0.006	0.007
Firm FE	NO	NO	YES	YES	NO	NO	YES	YES	NO	NO	YES	YES
Firms			70,736	70,736			70,736	70,736			9,174	9,174
Figure	5	5	5	5			6	6			8	8
	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)
	Average Size								**Share of Employment**			
	All Firms - HQ		ME Firms - HQ		ME Firms - non HQ		All Firms - HQ		ME Firms - HQ		ME Firms - Non HQ	
N	688,958	688,958	130,292	130,292	61,303	130,292	687,481	687,481	130,108	130,108	61,303	61,303
R2	0.000	0.002	0.000	0.002	0.000	0.002	0.001	0.006	0.003	0.021	0.002	0.001
Firm FE	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Firms		70,736		9,174		9,174		70,707		9,174		9,174
Figure		A4		A4		A4				4		4
	(23)	(36)	(37)	(38)	(39)	(40)	(41)	(42)	(43)	(44)	(45)	(46)
	Average Distance to HQ - weighted by each Occupation's Employment											
	Managers		Business Services		Engineers + Science		Production		Clerical		Others	
N	270,026	270,026	268,925	268,925	209,141	209,141	344,469	344,469	392,213	392,213	335,033	335,033
R2	0.000	0.001	0.000	0.002	0.000	0.002	0.001	0.001	0.001	0.002	0.000	0.002
Firm FE	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Firms		36,121		37,967		31,855		44,022		50,525		51,616
Figure		9		9		9		9		9		9
	(47)	(48)	(49)	(50)	(51)	(52)	(53)	(54)				
	Managers to P+C Ratio											
	Firm Level		Establishment Level		Est. - Main Municip.		HQ and non-HQ Est.					
N	464,384	464,384	582,687	582,687	582,687	582,687	582,687	582,687				
R2	0.007	0.005	0.006	0.005	0.022	0.007	0.012	0.006				
Firm FE	NO	YES	NO	YES	NO	YES	NO	YES				
Establ.		50,917		67,032		67,032		67,032				
Figure	A12	10	A12	10		12	A12	11				

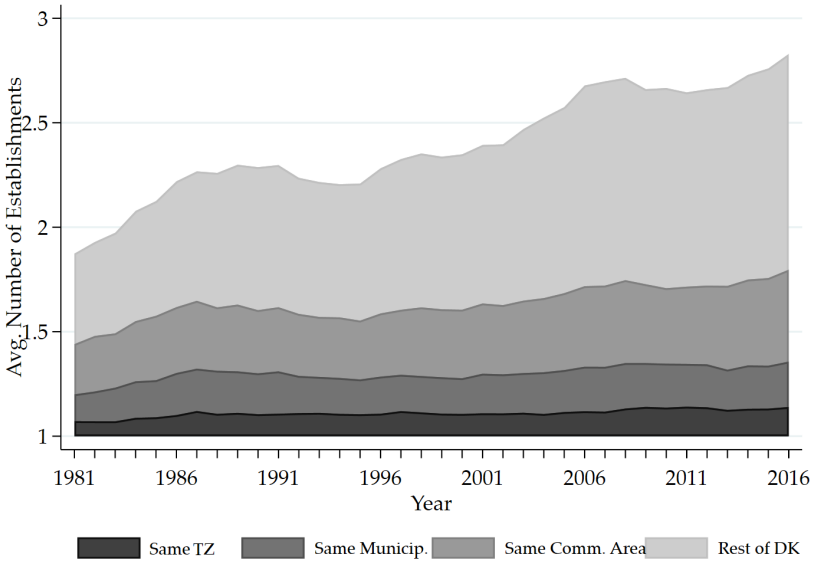
This table shows the observations, R^2, and number of firms (or establishments) for most of the regressions used in the paper in building the relevant figures, together with their respective counterparts, which do not use the firm (or establishment) fixed effects. All regressions use year fixed effects. The table also shows the figure that corresponds to the regressions.

Figure A2: Average Number of Establishments - Multi-Establishment Firms

Panel A: Evolution

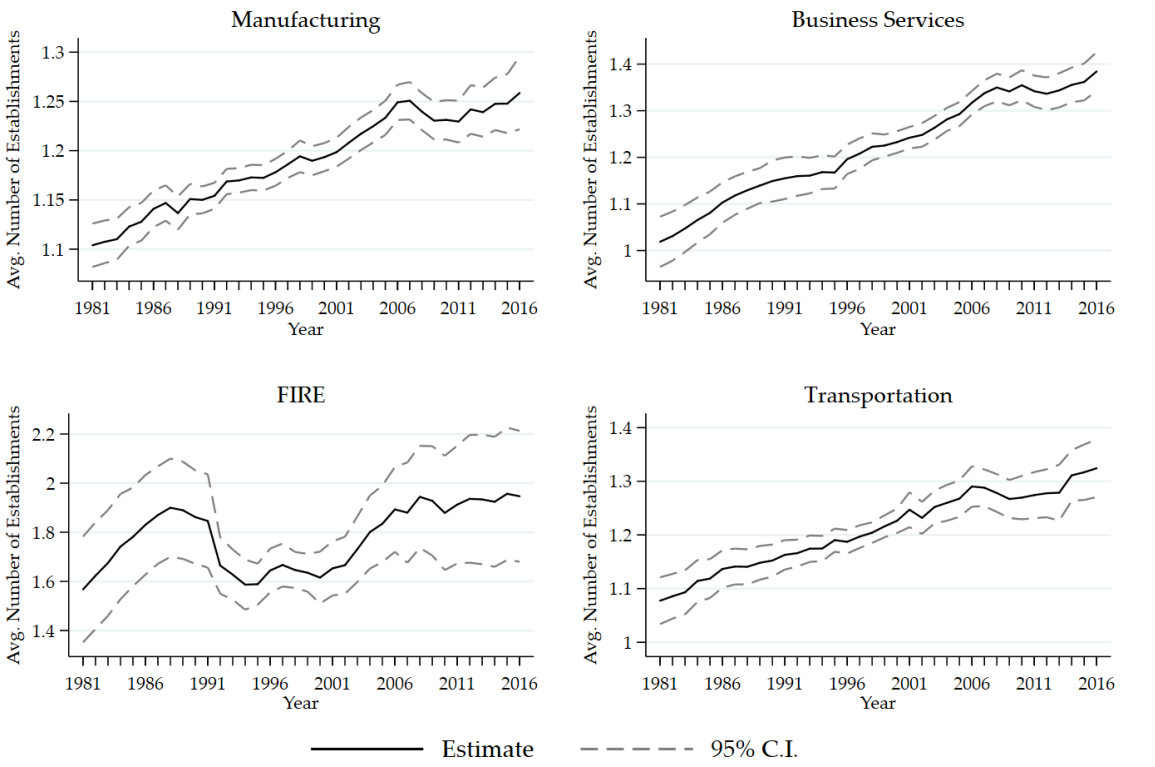


Panel B: Decomposition



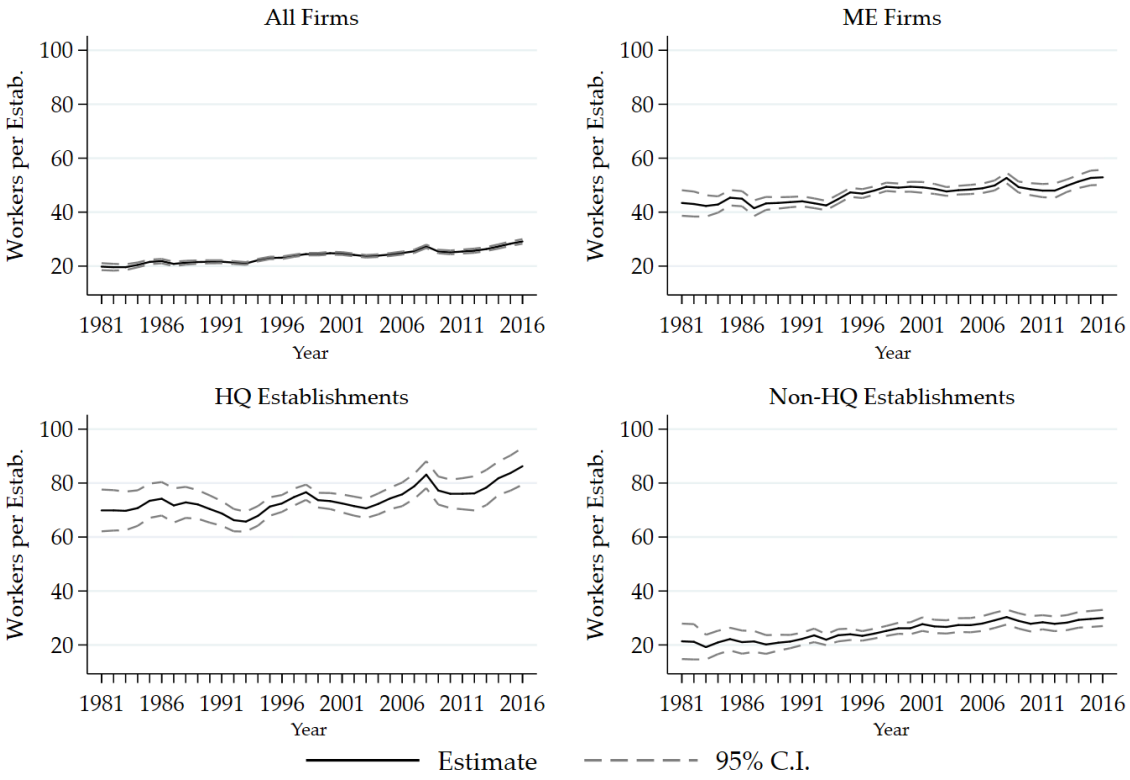
Panel A in this figure shows the estimated year fixed effects from a regression of each firm's total number of establishments on year and firm fixed effects, using only firms that had multiple establishments at some point between 1981 and 2016. Panel B shows the evolution of the total number of establishments from a regression of each firm's total number of establishments on year and firm fixed effects, separating between those establishments located in the same traffic zone (TZ) as their HQ, same municipality, same commuting area, and rest of the country, and using only firms that had multiple establishments at some point between 1981 and 2016.

Figure A3: Evolution of the Total Number of Establishments



This figure shows the estimated year fixed effects from a regression of each firm's total number of establishments on year and firm fixed effects, separating by each one of these four sectors.

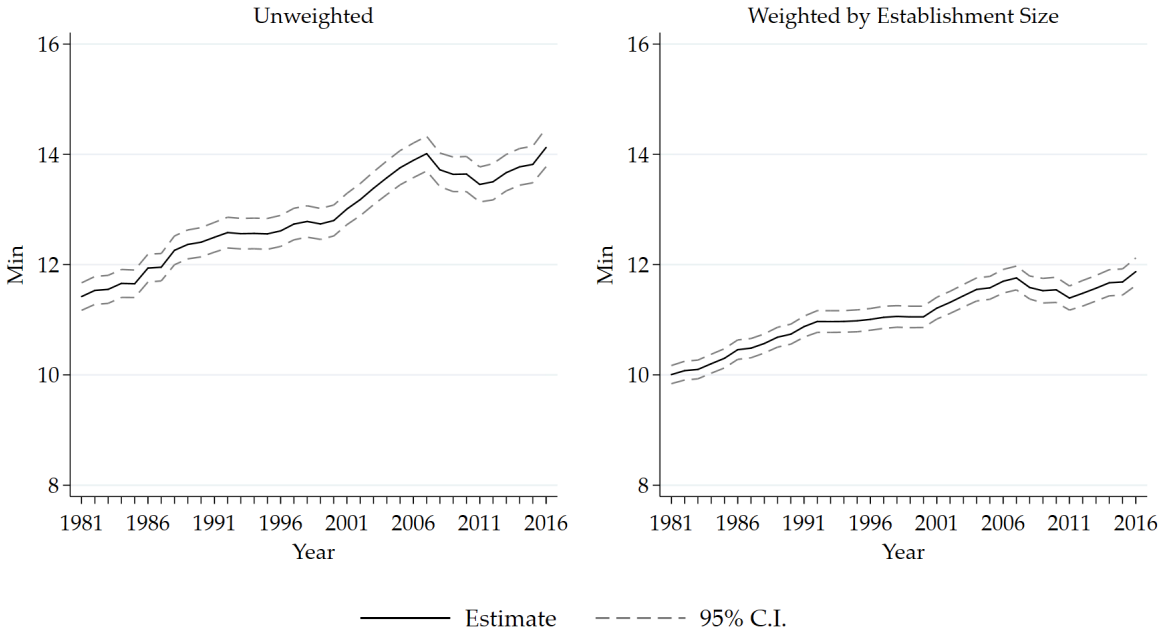
Figure A4: Evolution of the Average Establishment Size



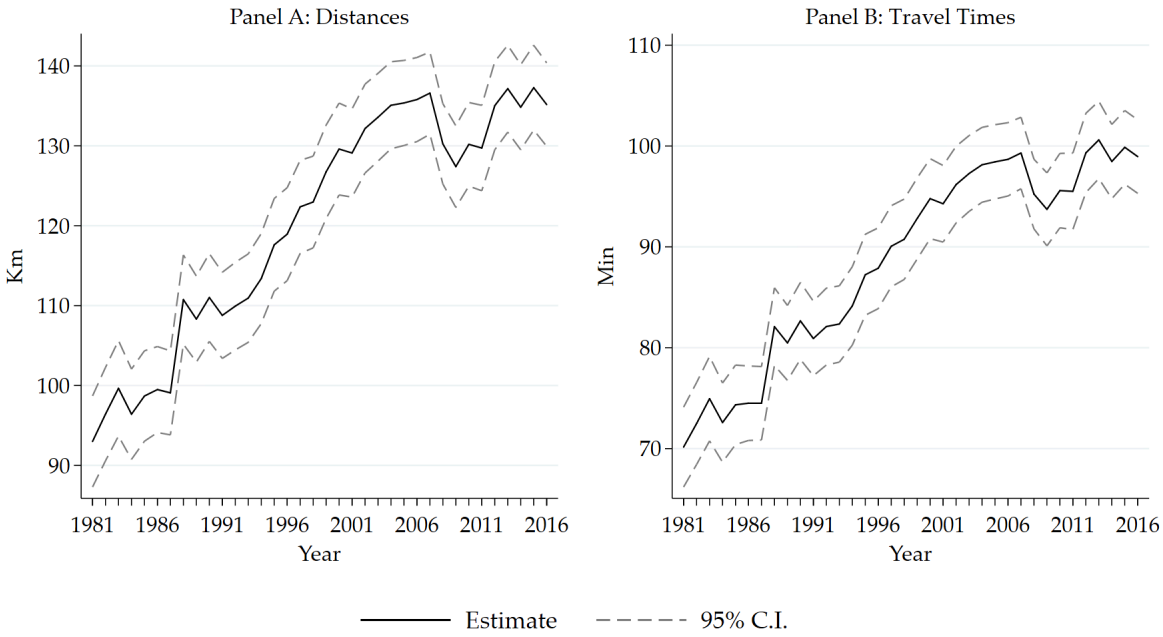
This figure shows the estimated year fixed effects from a regression of each firm's average number of workers per establishment type (all, HQ, or non-HQ) on year and firm fixed effects.

Figure A5: Measures of Spatial Decentralization - Raw Data

Panel A: Average Travel Time between Establishments and Headquarters

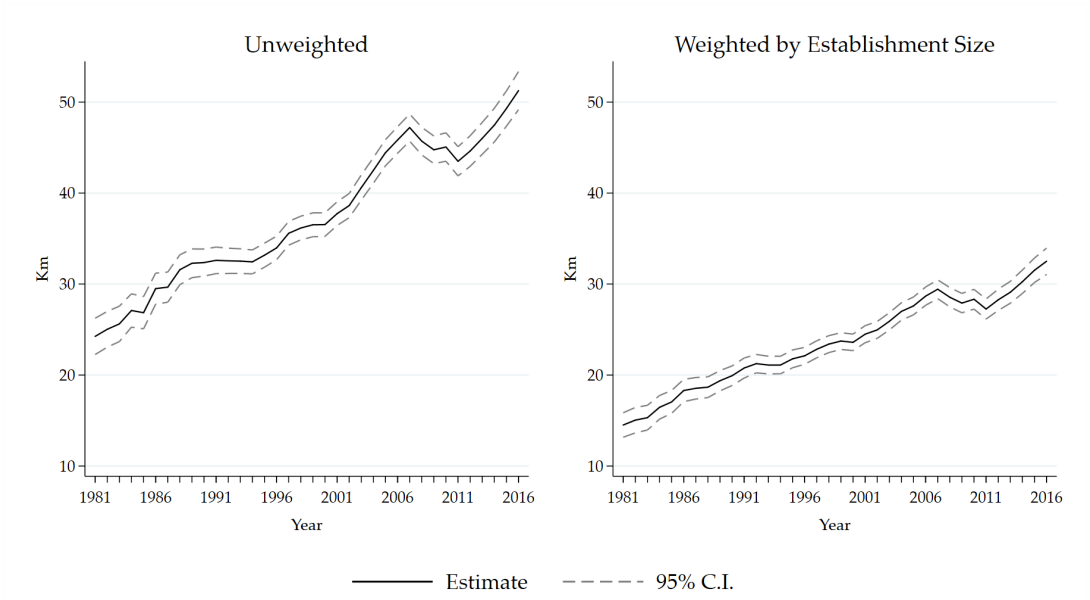


Panel B: Average Distance between Establishments and Headquarters - Excluding HQ



This figure shows the estimated year fixed effects from a regression of each firm's average distance (Panel A) or average travel time (Panel B) between its establishments and HQ on year and firm fixed effects. In the left panels, we use unweighted averages; in the right panels, we weight by the total number of workers in the establishment.

Figure A6: Average Distance between Establishments and Headquarters for Multi-establishment Firms



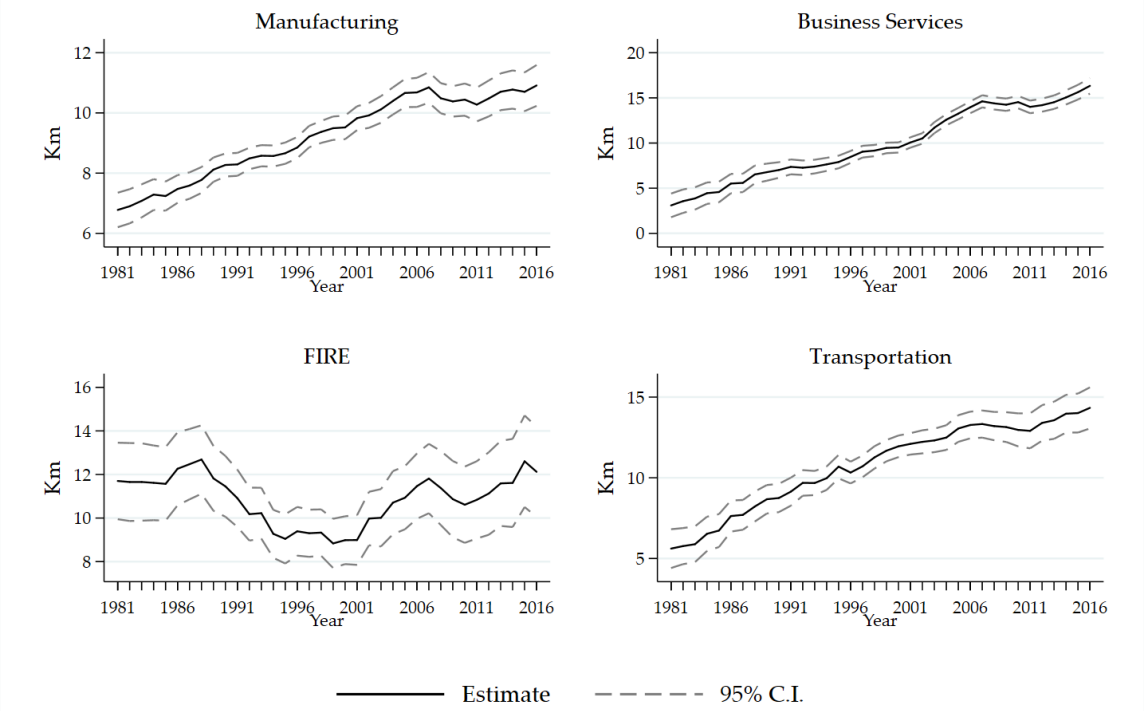
This figure shows the estimated year fixed effects from a regression of each firm's average distance between its establishments and headquarters on year and firm fixed effects, using only firms that had multiple establishments at some point between 1981 and 2016. In the left panel, we use an unweighted average distance, and in the right panel, we weight by the total number of workers in the establishment.

Figure A7: Maximum Distance between Establishments and Headquarters

This figure shows the estimated year fixed effects from a regression of the maximum distance between a firm's establishment and its HQ on year and firm fixed effects. In the left panel, we use all firms, and in the right panel, we use only firms that had multiple establishments at some point between 1981 and 2016.

Figure A8: Average Distance between Establishments and Headquarters by Sectors

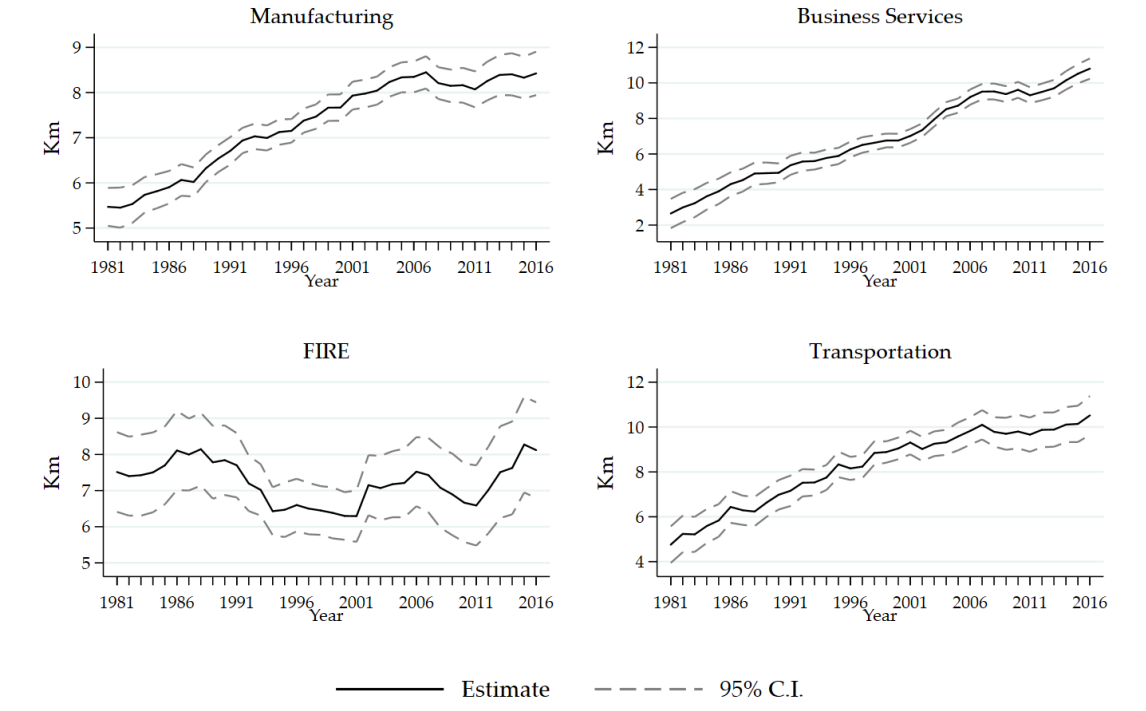
Unweighted



This figure shows the estimated year fixed effects from a regression of each firm's (unweighted) average distance between its establishments and headquarters on year and firm fixed effects, separating by each one of these four sectors.

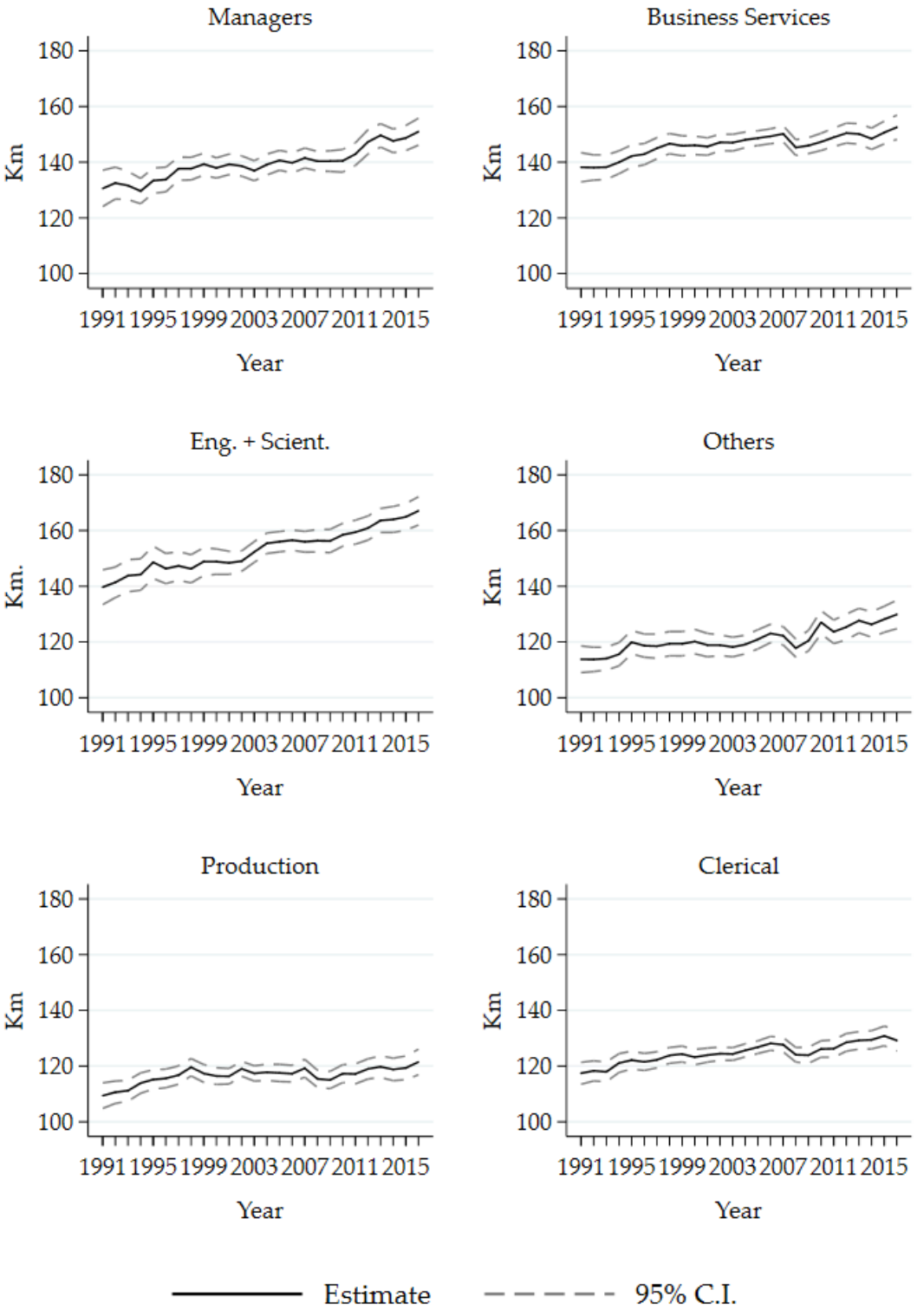
Figure A9: Average Distance between Establishments and Headquarters by Sectors

Weighted by Number of Workers



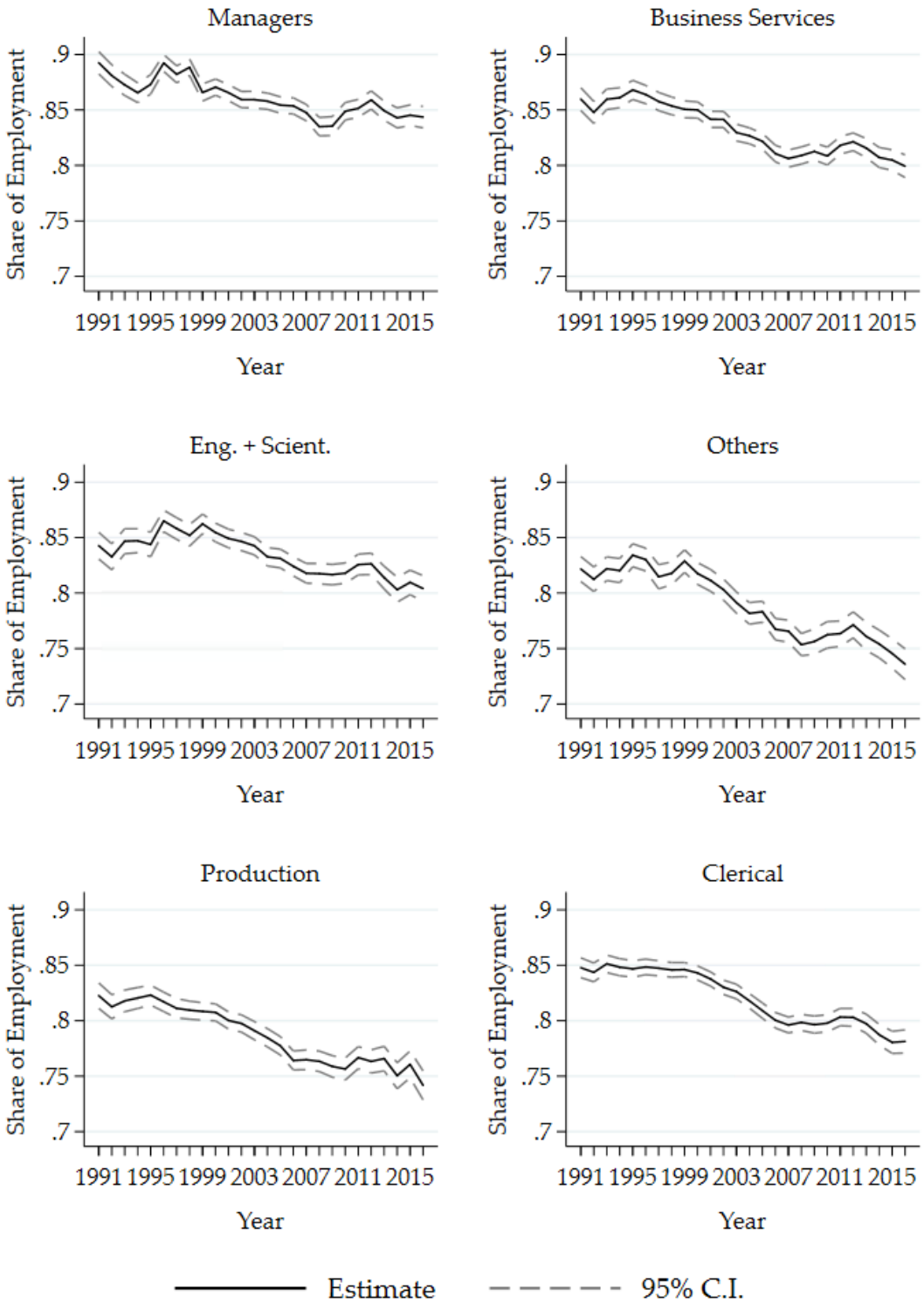
This figure shows the estimated year fixed effects from a regression of each firm's (weighted by the number of workers) average distance between its establishments and headquarters on year and firm fixed effects, separating by each one of these four sectors.

Figure A10: Average Distance to the HQ by Occupation - Excluding Headquarters



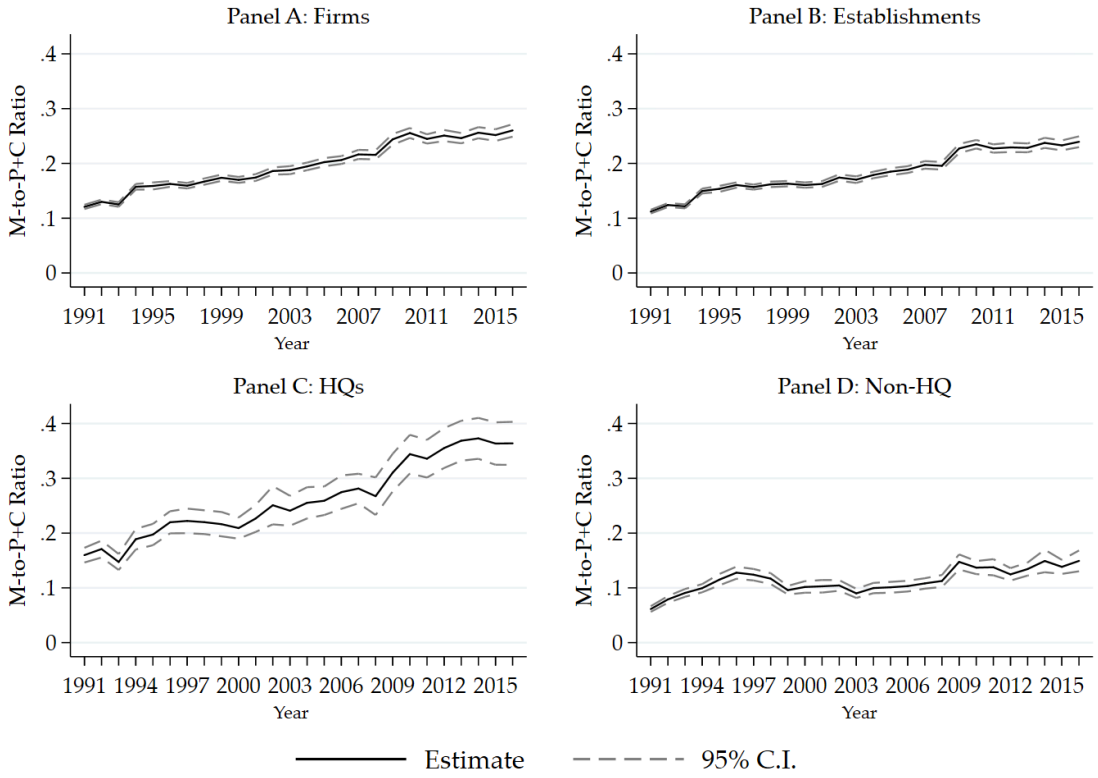
This figure shows the estimated year fixed effects of a regression of each firm's average distance of the establishments to their HQ (weighted by the establishment's relative number of employees within each occupation category) on year and firm fixed effects.

Figure A11: Concentration of Employment at the HQ by Occupation



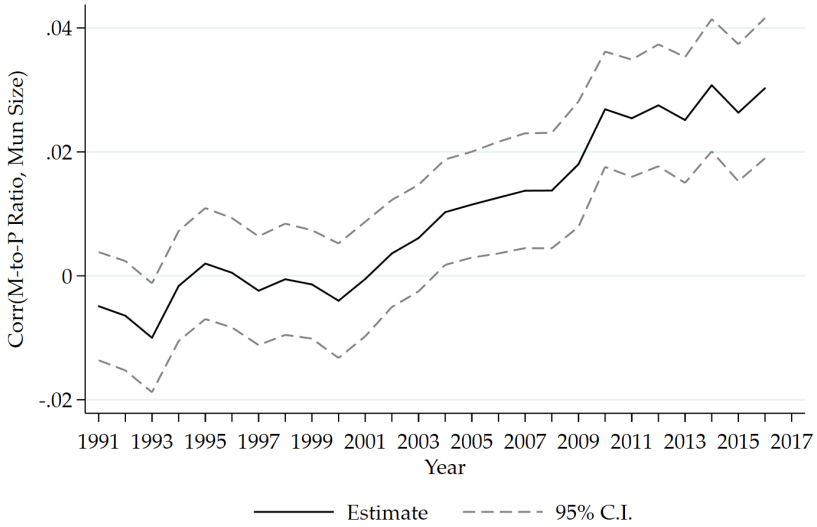
This figure shows the estimated year fixed effects of regressions of each firm's share of employment at their HQ for each occupation on year and firm fixed effects using only those firms that had multiple establishments at some point between 1981 and 2016.

Figure A12: Managers to Production and Clerical Workers - Raw Data



This figure shows the evolution of the ratio of managers to production and clerical workers (M-to-P+C) within firms and establishments. Panel A plots the estimated year fixed effects from a regression of each firm's ratio on year fixed effects. Panel B plots the estimated year fixed effects from a regression of each establishment's ratio on year fixed effects. Panels C and D run the same regression for only HQ and non-HQ establishments, respectively.

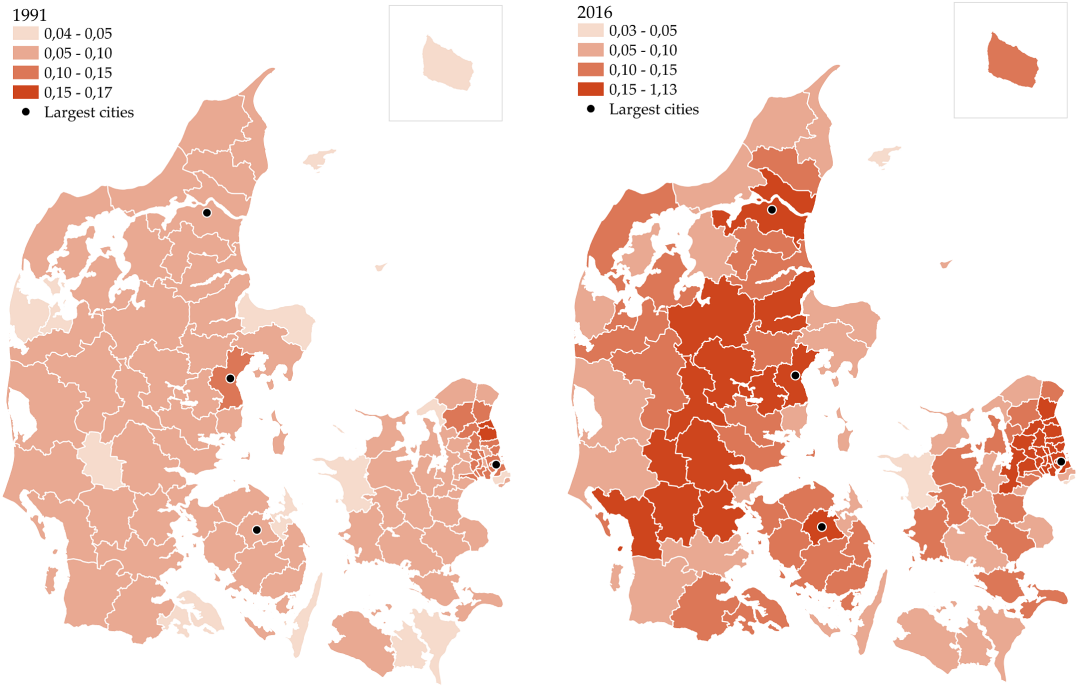
Figure A13: Managers to Production and Clerical Workers and Municipality Size



This figure shows the estimated year times municipality size fixed effects of regressions of each establishment's managers to production and clerical workers ratio on year, firm, and year times municipality size fixed effects.

Figure A14: Managers to Production and Clerical Workers Ratio by Municipality

1991 Levels - 2016 Levels



This figure shows the average ratio of managers to production and clerical workers across establishments for each municipality in 1991 (left panel) and 2016 (right panel). Black dots denote the largest municipalities: Copenhagen, Aarhus, Aalborg, and Odense.

B Data Appendix

In this appendix we describe which occupations belong to each one of the six occupational categories we use throughout the paper and the criteria we followed in selecting the sample we use for our empirical exercises.

B.1 DISCO Categories

DISCO is the Danish version of the International Standard Classification of Occupations (ISCO) and is only available from 1991. This classification changed between 2009 and 2010 from DISCO88 to DISCO08. Information on the crosswalk used is available upon request. For most of the analysis, we aggregate 4-digit DISCO codes into six categories: managers, business services workers, engineers and scientists, clerical workers, production workers, and other workers, as follows:

Table A3: Occupation Categories

Category	**DISCO Codes (ISCO)**
Managers	1000-1999
Production Workers	60-83, 92-93
Business Services Workers	2400-2419, 242, 2440-2449, 3400-3439, 344, 346-347
Clerks	243, 40-52, 90-91
Engineers and Scientists	200, 21, 220-222, 231, 311-312, 32

Finally, we build an "Others" category that contains every occupation that is not included in any of the categories defined above. For example, groups such as "Other Associate Professionals," "Primary Education Teaching Professionals," or "Authors, Journalists and Other Writers." This category also includes those workers with a missing DISCO code.

B.2 Data Selection Criteria

Section 2.3 in the text describes the criteria we followed to clean our data and define our sample. Taking these criteria into account, Table A4 shows the number of observations left after each step. The parentheses below each number show the share of this total of the total labor force in the private sector.

C Estimating Equations

This appendix presents the estimating equations for the figures in our paper.

Table A4: Data Selection Criteria

	Workers	Establishments	Firms
Totals (1981-2016)			
In the economy	90,165,404	6,657,020	5,237,107
In private sector	60,346,107	5,646,343	4,827,549
	(100%)	(100%)	(100%)
Within manufacturing, transportation, business services, and FIRE	31,895,266 (52.85%)	2,098,456 (37.16%)	1,712,395 (35.47%)
Totals after dropping:			
Establishments with no location or in small municipalities	31,429,892 (52.08%)	2,039,947 (36.13%)	1,682,649 (34.86%)
Establishments that only lived one year	31,314,545 (51.89%)	2,015,230 (35.69%)	1,662,871 (34.45%)
Firms that had fewer than 4 employees for more than 66% of their lives	28,970,535 (48.01%)	1,086,685 (19.25%)	741,554 (15.36%)
Establishments with fewer than 3 workers	28,792,656 (47.71%)	964,269 (17.08%)	689,462 (14.28%)
Firms with outliers in changes in the number of establishments	27,057,805 (44.84%)	921,597 (16.32%)	689,226 (14.28%)
Firms with 99+ establishments	25,397,415	871,673	688,958
	(42.09%)	**(15.44%)**	**(14.27%)**

C.1 Firm Fragmentation

In order to study the evolution of the average number of establishments per firm from Figure 3, we run the following regressions:

$$\begin{aligned} Esta_{ft} &= \delta_t + \varepsilon_{ft}, \\ Esta_{ft} &= \alpha_f + \delta_t + \varepsilon_{ft}, \end{aligned} \tag{A1}$$

where $Esta_{ft}$ denotes the number of establishments of a firm f in time t, α_f are firm fixed effects, and δ_t time fixed effects. For the figures by sector, we estimate equation (A1) for firms belonging to each of the sectors.

For the evolution of the share of workers employed at the firm's HQ from Figure 4, we estimate the following regressions:

$$\frac{L_{HQ,t}}{L_{f,t}} = \alpha_f + \delta_t + \varepsilon_{ft}, \tag{A2}$$

$$\frac{L_{N,t}}{L_{f,t}} = \alpha_f + \delta_t + \varepsilon_{ft}, \tag{A3}$$

where α_f are firm fixed effects and δ_t time fixed effects, $L_{f,t}$ denotes the total number of workers in firm f and time t,$L_{HQ,t}$ denotes the total number of workers at their HQ in time t, and $L_{N,t}$ denotes the average number of workers across the firm's f non-HQ establishments in time t.

We run these regressions using only those firms that had multiple establishments at some point between 1981 and 2016. For Figure A11, we compute the share $\frac{L_{N,t}}{L_{f,t}}$ for each occupation and run the respective regression for each.

C.2 Spatial Decentralization

In order to study the evolution of the average distance of establishments from the HQ in Figure 5, we start by defining it as:

$$\bar{D}^u_{ft} = \frac{1}{E_{ft}} \sum_j dist_{j,HQ},$$

where $\bar{D}^u_{ft}$ denotes the average distance between the firm's establishments and its HQ, E_{ft} denotes the number of establishments of a firm f in time t, and $dist_{j,HQ}$ the distance of a particular establishment j from the HQ. We also compute a weighted version of this distance, where the weight of each establishment corresponds to its relative number of workers:

$$\bar{D}^w_{ft} = \sum_j dist_{j,HQ} \left(\frac{L_{jt}}{L_{ft}} \right), \tag{A4}$$

where L_{jt} is the total employment in establishment j and L_{ft} is the total employment in the firm at time t. We then run the following regressions for each of these two variables:

$$\begin{aligned} \bar{D}_{ft} &= \alpha_f + \delta_t + \varepsilon_{ft}, \\ \bar{D}_{ft} &= \alpha_f + \delta_t + \varepsilon_{ft},, \end{aligned} \tag{A5}$$

where $\bar{D}_{ft}$ denotes either $\bar{D}^u_{ft}$ or $\bar{D}^w_{ft}$. The estimated fixed effects of these regressions are presented in Figure 5. For the figures by sector, we estimate equation (A5) for firms belonging to each of the sectors. For Figure 6, we compute the dependent variable using travel times between establishments and the HQ. For Figure 8, we compute the respective dependent variable excluding the distance or travel time from the HQ to itself.

For the decomposition in Figures 7 and Panel B in A2, we estimate equation (A1) using as dependent variables the total number of establishments inside the same traffic zone as the firm's HQ, in the same municipality (but outside the traffic zone) as the HQ, in the same commuting area (but outside the municipality) as the HQ, or in the rest of the country.

C.3 Functional Specialization

For Figure 9, we estimate regressions similar to equation (A1), but the dependent variables are defined as

$$\bar{Dist}^o_{ft} = \sum_j dist_j \left(\frac{L_{ojt}}{L_{oft}} \right), \tag{A6}$$

where L_{ojt} is the total employment of occupation o in establishment j and L_{oft} is the total employment of occupation o in the firm at time t. For Figure A10, we compute the respective distances excluding the distance from the HQ to itself. For Figure A11, we estimate equation (A2) for each occupation separately.

C.3.1 Decomposition

For the decomposition presented in Table 1, we take equation (A4)

$$\bar{D}_{ft} = \sum_j dist_j \left(\frac{L_{jt}}{L_{ft}} \right) = \sum_j dist_j \left(\frac{\sum_o L_{ojt}}{L_{ft}} \right),$$

where o denotes an occupation. Multiplying and dividing inside the summation by the number of people in an occupation o inside firm L_{oft}, we can rewrite this expression as

$$\bar{D}_{HQ,t} = \sum_o \frac{L_{oft}}{L_{ft}} \left[\sum_j dist_j \left(\frac{L_{ojt}}{L_{oft}} \right) \right] \equiv \sum_o \underbrace{\left(\frac{L_{of}}{L_f} \right)_t \bar{Dist}^o_{ft}}_{\bar{D}^o_{ft}}, \tag{A7}$$

which is Equation (1) in the text. To obtain the contribution of each occupational category to the average distance of workers to the HQ, we run the following regression for each occupation o:

$$\bar{D}^o_{ft} = \alpha_f + \delta^o_{dec,t} + \varepsilon_{ft}.$$

Then, we use the estimate of the year fixed effects as the predicted average value of $\hat{\bar{D}}^o_t = \hat{\delta}^o_{dec,t}$ for each occupation o in year t.

To further decompose each occupation's contribution between the firm's relative use of the occupation and the average distance of workers from this occupation to the HQ, we start by running a regression:

$$\frac{L_{oft}}{L_{ft}} = \alpha_f + \delta^o_{use,t} + \varepsilon_{ft}.$$

Similarly, we use the estimate of the year fixed effects as the predicted average value of the relative use of each occupation $\widehat{\frac{L_{ot}}{L_t}} = \hat{\delta}^o_{use,t}$. Finally, we compute the predicted average distance of workers in an occupation o to the HQ as $\hat{\bar{Dist}}_{ot} = \hat{\delta}^o_{dec,t} / \hat{\delta}^o_{use,t}$. Using these predicted averages, we can define for each occupation and year:

$$\hat{\bar{D}}^o_t = \widehat{\frac{L_{ot}}{L_t}} \cdot \hat{\bar{Dist}}_{ot}.$$

In particular, consider the change in $\hat{\bar{D}}^o$ between 1991 and 2016:

$$\Delta_{25}\hat{\bar{D}}^o \equiv \hat{\bar{D}}^o_{2016} - \hat{\bar{D}}^o_{1991} = \frac{\hat{L_{o,2016}}}{L_{2016}} \cdot \hat{\bar{Dist}}_{o,2016} - \frac{\hat{L_{o,1991}}}{L_{1991}} \cdot \hat{\bar{Dist}}_{o,1991}. \tag{A8}$$

Adding and subtracting $\frac{\hat{L_{o,1991}}}{L_{1991}} \cdot \hat{\bar{Dist}}_{of,2016}$ to the right-hand side of the equation, we can rewrite it as

$$\Delta_{25}\hat{\bar{D}}^o = \Delta_{25}\left(\frac{\hat{L_o}}{L}\right) \cdot \hat{\bar{Dist}}_{o,2016} + \Delta_{25}\hat{\bar{Dist}}_o \cdot \frac{\hat{L_{o,1991}}}{L_{1991}}. \tag{A9}$$

We use Equation (A10) to decompose the contribution of each of the occupational categories into two parts: changes in the relative use of the occupation and changes in the average distance of workers in this occupation to the HQ. Alternatively, we could add and subtract $\frac{\hat{L_{o,2016}}}{L_{2016}} \cdot \hat{\bar{Dist}}_{of,1991}$ to the right-hand side of equation (A8). The results obtained from this alternative decomposition are very similar to the ones we show in Table 1 and are available on request.

Furthermore, we decompose the changes in the use of each occupation into changes in their use at the HQ, establishments relatively close to the HQ, and establishments relatively far from the HQ. Using a similar procedure, we derive the following expression:

$$\Delta_{25}\hat{\bar{D}}^o = \left[\Delta_{25}\left(\frac{\hat{L_{o,hq}}}{L}\right) + \Delta_{25}\left(\frac{\hat{L_{o,c}}}{L}\right) + \Delta_{25}\left(\frac{\hat{L_{o,l}}}{L}\right)\right] \hat{\bar{Dist}}_{o,2016} + \Delta_{25}\hat{\bar{Dist}}_o \cdot \frac{\hat{L_{o,1991}}}{L_{1991}},$$

where we denote with the subindices c and l those establishments that are relatively close and relatively far from the HQ, respectively.

C.4 Reduction in the Span of Control

In order to study the evolution of the ratio of managers (M) to production and clerical workers ($P + C$) in Figure 10, we estimate the following regressions separately:

$$\left(\frac{M}{P+C}\right)_{ft} = \alpha_f + \delta_t + \varepsilon_{ft}, \tag{A10}$$

$$\left(\frac{M}{P+C}\right)_{jft} = \alpha_j + \delta_t + \varepsilon_{jft}, \tag{A11}$$

where j denotes an establishment, f denotes a firm, α_j are establishment fixed effects, α_f are firm fixed effects, and δ_t are time fixed effects. For Figure 12, we estimate equation (A10), but include an interaction between year fixed effects and municipality category:

$$\left(\frac{M}{P+C}\right)_{jft} = \alpha_j + \delta_{c,t}\mathbf{1}_{\{j,CPH\}} + \delta_{a,t}\mathbf{1}_{\{j,Aarhus\}} + \delta_{a,t}\mathbf{1}_{\{j,Rest\}} + \varepsilon_{jft},$$

where $\mathbf{1}_{\{j,X\}}$ is an indicator function that equals 1 if the establishment j is located in $X \in \{CPH, Aarhus, Rest\}$, and CPH denotes Copenhagen metropolitan area, which we define as

the municipality of Copenhagen, its surroundings, and Northern Zealand. For Figure A13, we estimate:

$$\left(\frac{M}{P+C}\right)_{jft} = \alpha_j + \delta_t + \beta_t \log(N_{jt}) + \varepsilon_{jft},$$

where $\log(N_{jt})$ denotes the logarithm of the number of the workers in the municipality where the establishment j is located. In Figure 11, we estimate equation (A10), but include an interaction between year fixed effects and a dummy variable that equals one when the establishment is a HQ establishment:

$$\left(\frac{M}{P+C}\right)_{jft} = \alpha_j + \delta_t + \beta_t \mathbf{1}_{\{j,HQ\}} + \varepsilon_{jft}. \tag{A12}$$

Finally in Figure A12, we estimate equations (A11), (A10), and (A12) without including firm or establishment fixed effects. This is equivalent to showing the yearly averages with the raw data.