The Internal Spatial Organization of Firms: Evidence from Denmark*

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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 novel results regarding the internal spatial organization of firms. First, the average number of establishments per firm increased by 21%. Second, the average distance of establishments and workers from their headquarters about doubled. Third, firms achieved this fragmentation by concentrating managers at headquarters locations and decentralizing jobs in production and business services occupations. Fourth, the ratio of managers to production and clerical workers within firms increased by 80%, driven particularly by headquarters and establishments located in the largest cities These facts imply that firms are not simply becoming more spatially dispersed; instead, they are fragmenting into functions.

JEL: L22, L23, R00, R30.

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

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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) document that the pattern of specialization is shifting from sectoral to functional by showing 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. Furthermore, the changing spatial organization of activities within firms is sufficiently large to explain changes in occupational structure and wage dispersion across space (Spanos, 2017; Acosta and Lyngemark, 2020).

In this paper, 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.[2] Studying the changes in the spatial organization of these firms is necessary before addressing questions concerning the causes and consequences of these changes.

We study these spatial organizational patterns using Danish administrative employer- employee matched data between 1981 and 2016. 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, which are areas significantly smaller than municipalities. These detailed locations allow us to compute precise measures of firm decentralization without making strong assumptions regarding the location of establishments within a municipality or a county, as has been common in the literature.

We lay out four facts that describe the evolution of the spatial organization of firms since 1981. These facts are new in the literature and represent the main contribution of this paper. First, 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, the spatial decentralization within firms has increased over time. Specifically, the average distance between firms' establishments and their headquarters (HQ) about doubled during the last four decades. This increase primarily comes because firms' new establishments have opened farther from HQ. Moreover, firms have reallocated jobs from HQ to more distant establishments.

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

[2] The relevance of ME firms is not specific to Denmark. Among other examples, ME firms employed more than 55% of workers in the private sector in the US in 1997 and more than 40% in France in 2011 (Aarland et al., 2007; Charnoz et al., 2018).

Third, the increase in the distance to HQ has not been uniform across all occupations. In particular, increases in the average distance of workers in production, engineering, and business services occupations to their HQ account for 70% of the total increase in distance. On the other hand, increases in the average distance of managerial occupations to their HQ have been small (4%), while the use of managers has increased. These results point the existence of within establishment complementarities between some high-skilled occupations. Fourth, the ratio of managers to production and clerical workers increased by 12 percentage points (or 80%). This increase has been particularly large in HQ and establishments located in Copenhagen and Aarhus. Finally, our results suggest that the location and labor demand decisions of ME firms account for 51% of the increase in functional specialization observed in the data.

All of these facts show 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. Thus, 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. For instance, as ME firms are more likely to locate their HQ in larger cities, cities that retain them will be increasingly dominated by high-skilled, high-paid workers, which has clear implications for economic inequality and the operation of local labor markets.

This paper relates to the literature that studies the location decisions of ME firms and the agglomeration of HQ (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, a new location has to offer something beneficial for the firm, such as a larger variety of business services, to outweigh the higher communication and coordination costs. Most of these papers study 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.[3]

To our knowledge, our paper is the first to empirically study changes in the internal spatial organization of firms along the extensive margin (location of the firm's establishments) and the intensive margin (distribution of workers across establishments). This allows us to understand the structure of firms and their possible effects on local economies in a more holistic way. In this regard, 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).

This paper also contributes to the literature studying firm organization and its relation to

[3]Our analysis is also guided by theoretical studies that examine firm fragmentation decisions, such as Ota and Fujita (1993); Duranton and Puga (2005); Rossi-Hansberg et al. (2009); and Gokan et al. (2019).

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). Moreover, we contribute to the literature in management sciences studying multi-unit corporations and the role of corporate HQ, such as Chandler (1969); Fligstein (1985); Collis et al. (2007); and Menz et al. (2015). This research tends to use qualitative methods or data for a few large firms, while our data cover the universe of firms within a country.

The location of establishments and firms has been studied in other fields within economics. First, in the international trade literature through the study of multinational enterprises (Antràs and Yeaple, 2014). We consider a firm's decision to become a multinational to be a specific case of the firm fragmentation process. Second, in industrial organization through the study of market entry (Holmes, 2011; Aguirregabiria and Suzuki, 2016). Among others, Atalay et al. (2014) study vertical integration and outsourcing. 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.

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.

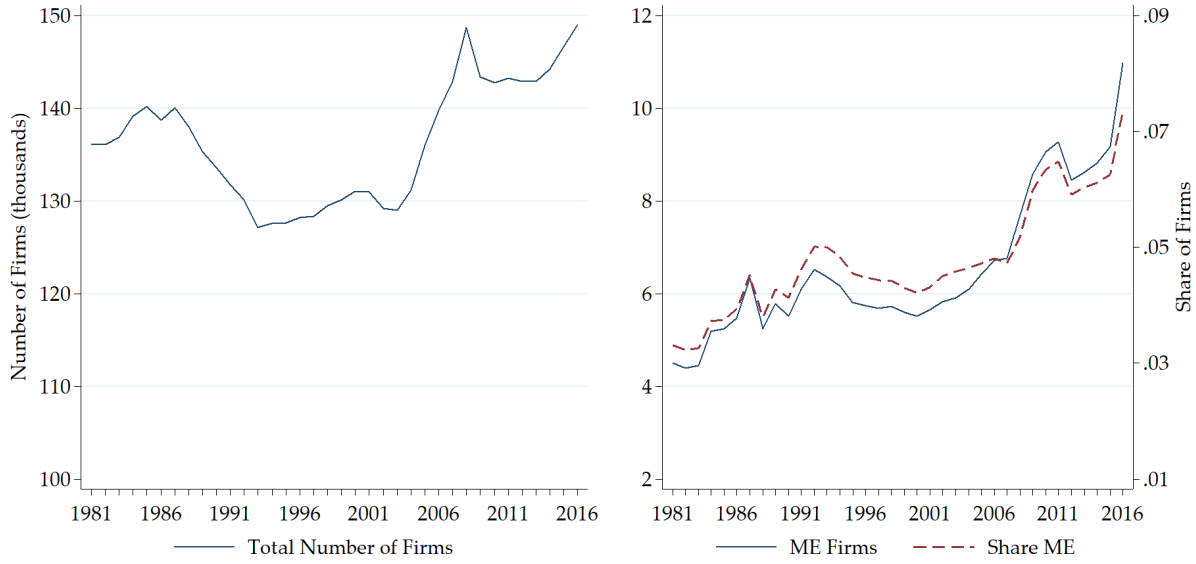
2.1 Denmark

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 it. 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 local markets offer, which encourage 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 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. Moreover, 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. Specifically, 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. We present these results in Panel A from Figure 3.

Figure 1: Evolution of Multi-establishment Firms in Denmark



This figure shows the evolution of the total number of firms, total number of ME firms, and the share of ME firms in Denmark between 1981 and 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. In Figure 2, we present a map of Denmark with its 98 municipalities, highlighting the four largest cities. Economic growth in these cities is mainly based on knowledge-intensive industries, such as the medical and business services sectors. 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 and Selection Criteria

Our data on firms, establishments, and workers come from several administrative registers in Statistics Denmark and contain the universe of employers and employees between 1981 and 2016. We start with the Integrated Database for Labor Market Research (IDA), which contains all matches between employees and their workplaces every year. These data associate each establishment, firm, and worker with unique identifiers. These identifiers allow us to determine whether a firm has one or multiple establishments and follow every worker through every establishment and firm in Denmark during this period.[4]

Even though the IDA reports the municipality in which establishments are located, municipalities outside the capital region are quite large. Therefore, we would have to make strong assumptions regarding establishments' locations and the distance between them.[5] For this reason, we merge 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). In Figure 2, we present a map of Denmark with its 98 municipalities (black borders) and 907 traffic zones (white borders), and a zoom-in image of the Copenhagen metropolitan area. On average, there are 9.25 traffic zones in each municipality.[6] The average traffic zone has an extension of 47.3 square kilometers (km), compared with 424.3 square km of the average municipality.[7]

The LTM includes the distance and travel time between all pairs of traffic zones, which are computed as a function of road size, quality and congestion. The LTM also includes average travel times within traffic zones. The average and median establishments of ME firms 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 highly 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 precise measures of firm decentralization. Using these locations, we define an establishment as the unique triplet between the establishment's 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 databases. First, with the Labor

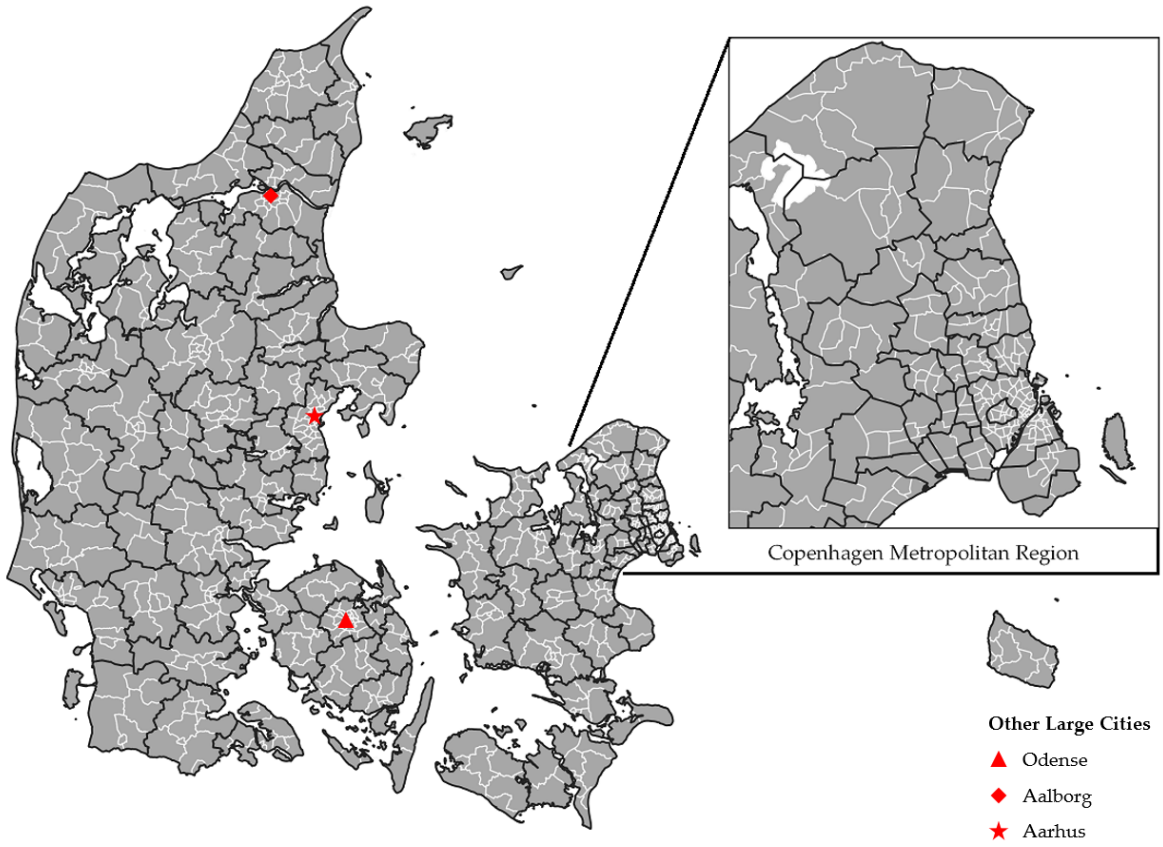
[4]Statistics Denmark defines a firm as an administrative unit that is subject to registration by the Danish Customs and Tax Agency, regardless of its level of activity (Statistics Denmark, 2016). An establishment is defined as an individual local business unit, which is an organizationally defined part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

[5]For example, that establishments are located in the centroids of their municipalities.

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

[7]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.

Figure 2: Municipalities and Traffic Zones in Denmark



This map shows Denmark with its 98 municipalities (black borders) and 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 star, diamond and triangle denote the location of Aarhus, Aalborg and Odense, respectively.

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.[8] 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. In particular, business services workers include accountants and business professionals, legal professionals, social science and related professionals, finance professionals, among others.[9] We also include the workers' 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 Den-

[8]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.

[9]Business services are closely related to the skilled scalable or prime services studied by Eckert et al. (2020) and Ahlfeldt et al. (2020), respectively. See Appendix B for a detailed list of occupations within each of the categories.

mark based on the worker's main source of income. In addition, we keep workers between 15 and 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 characteristic).

Second, we merge our database with firm records from the General Firm Statistics (FIRM) and the Accounting Statistics (FIRE), which are only available for most firms after 1999. From these registers, we are particularly interested in the value of production, total employment, and firm sector. In both databases, 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 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 mostly 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 number of (i) managers, (ii) high wage earners, (iii) workers with master's or doctorate degree, and (iv) workers with technical or bachelor's degree.

An important caveat of our data 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.[10] Therefore, our results should probably be interpreted as a lower bound of the actual decentralization and specialization patterns within firms.

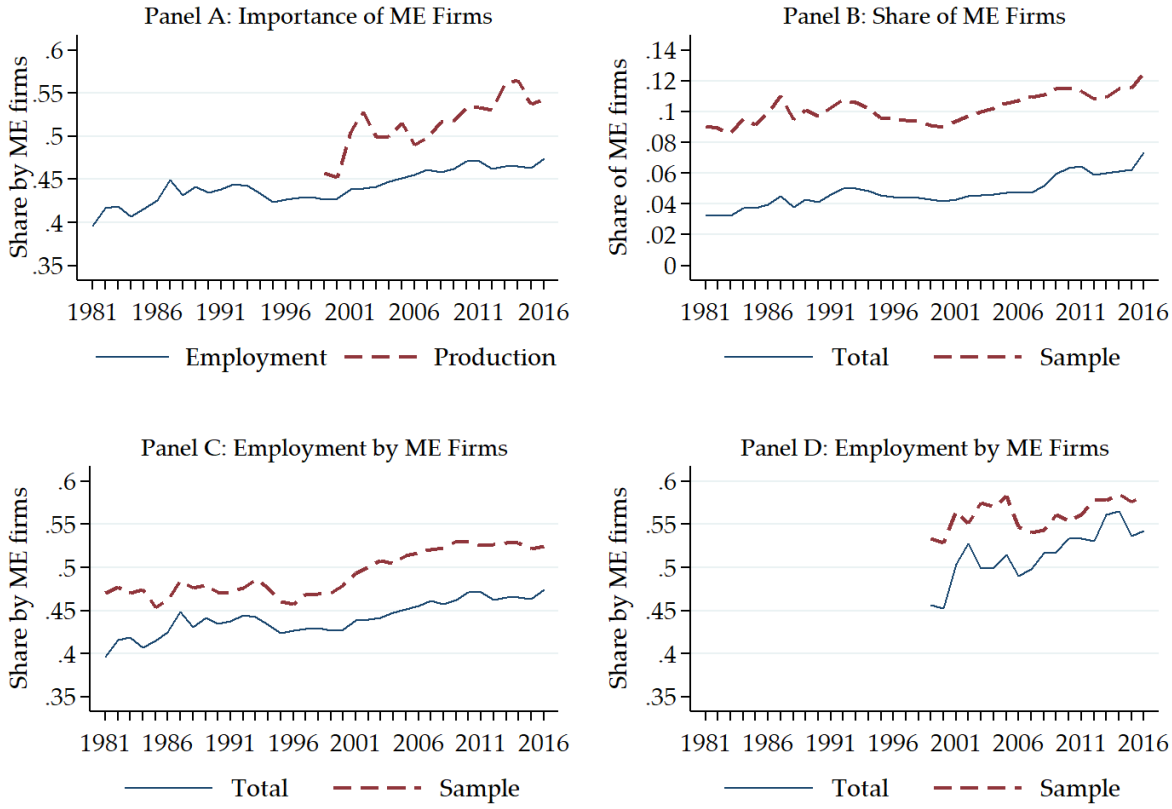
We restrict the sample to firms in manufacturing, transportation, business services, and finance, insurance and real estate (FIRE). Between 1981 and 2016, these sectors accounted on average for 22.7%, 7.8%, 14%, and 8.5% of total employment in the private sector, respectively. To ensure the quality of our data and results, we drop establishments with no reported location, those located in sparsely populated islands, and firms that had fewer than 4 employees for more than 66% of their existence in our database. This last restriction is important to avoid non-active firms. To avoid 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 or that only appear one year. Finally, to avoid outliers, we drop firms with more than 99 establishments or that exhibit large jumps in the total number of establishments across years. We present the details of our selection criteria in Appendix B.2 and, in Table A5, we present the number of observations left after each step. 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).

In Figure 3, we present 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

[10]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.

whole economy by around 5 to 6.5 percentage points (pp). Nonetheless, the behavior of both shares during this period is quite similar, which suggests that our sample captures 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. In terms of the labor force, workers in our sample have slightly higher levels of education, experience, and tenure, relative to the whole population. In terms of occupations, production and business services workers and engineers and scientists are slightly overrepresented in our sample, while managers and clerical workers are underrepresented. We show these statistics in Table A1, where differences between both columns are not substantive.

Figure 3: 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 ME firms in Denmark between 1981 and 2016. Panel B shows the share of ME firms in all of Denmark (solid line) and in our sample (dashed line). Panel C shows the share of employment generated by ME firms in all of Denmark (solid line) and in our sample (dashed line). Panel D shows the share of production generated by ME firms in all of Denmark (solid line) and in our sample (dashed line). The value of production is only available after 1999.

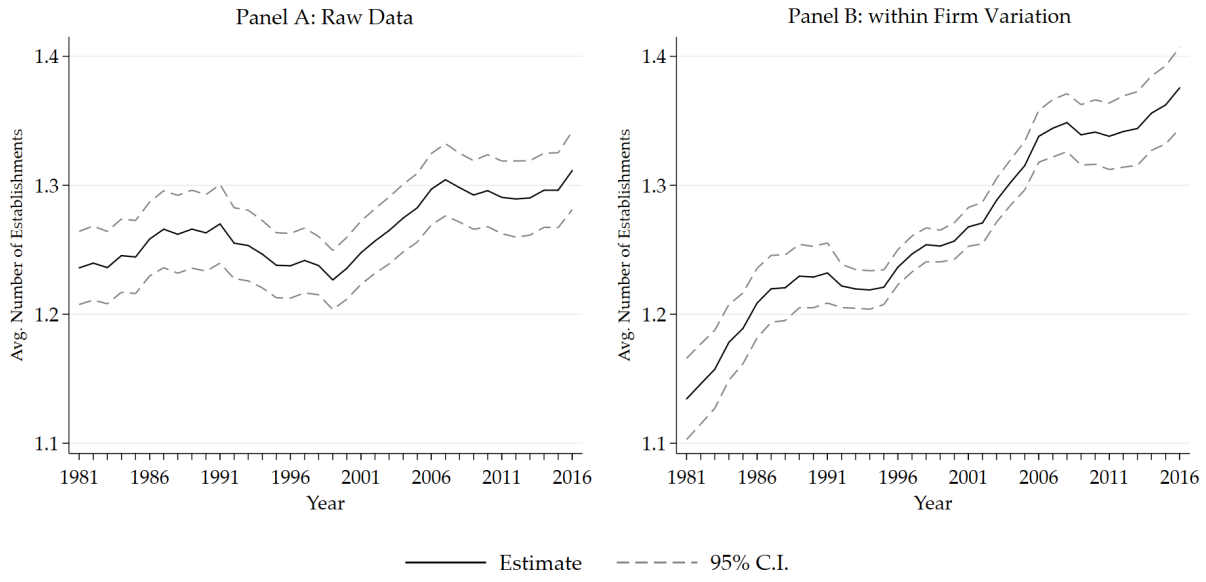
3 The Internal Spatial Organization of Firms

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 its changes during the three to four decades. Most of these facts are 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

We start by exploring the evolution of the average number of establishments per firm as an indicator of the degree of fragmentation within firms. In Panel A from Figure 4, we plot the yearly average of number of establishments per firm from our raw data. 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 it is barely significantly different from zero.

Figure 4: Evolution of the Average Number of Establishments per Firm



This figure shows the evolution of the average number of establishments per firm between 1981 and 2016. In Panel A, we plot the yearly averages coming from our raw data. In Panel B, we plot the estimated year fixed effects of a regression of each firm's number of establishments on firm and year fixed effects.

The observed increased in the average number of establishments per firm shown by the raw data could suggest a small degree of within-firm fragmentation during this period. However, the evolution of this indicator is also affected by changes in the composition of firms in the economy. For instance, the decrease in the average number of establishments observed in the early 1990s could reflect existing ME firms closing as a result of Denmark's economic slowdown

during those years. In order to separately identify within firm-fragmentation from changes in the composition of firms, we estimate the following regression:

$$Esta_{ft} = \alpha_f + \delta_t + \varepsilon_{ft}, \quad (1)$$

where $Esta_{ft}$ denotes the number of establishments of firm f in time t, α_f are firm fixed effects, and δ_t are year fixed effects. The inclusion of firm fixed effects in the regression implies that, the estimated year fixed effects are identified from firms that opened and/or closed establishments each year. Therefore, these fixed effects are capturing the evolution of the average number of establishments per firm coming from within firm-fragmentation and not from the selection of different types of firms into or out of the market.

We plot the estimated year fixed effects from this regression in Panel B from Figure 4. 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. These differences suggest that, even though most new firms are still single-establishment, on average existing firms have been opening more establishments over time. We present some relevant statistics from this and all other regressions from the paper in Table A2. 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 of establishments per firm: from 1.9 to 2.8, for a 51% increase (Figure A1). These findings constitute clear evidence of the increasing degree of within-firm fragmentation.

We summarize our first result as:

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

When we examine the change in the number of establishments per firm by sector, we find that the average number of establishments increased in all of the four sectors: business services (from 1.02 to 1.38, or 36%); transportation (from 1.08 to 1.33, or 23%); manufacturing (from 1.1 to 1.26, or 14%); and in the FIRE sector, although this is much less precisely estimated. We present these results in Figure A2. Each of these changes might be driven by different factors. For the manufacturing sector, it could be explained in part by the expansion of large ME firms within the country. For the business services sector, it could be explained by the generalized expansion of business services in the economy.[11]

The complete interpretation of Fact 1 depends on the evolution of the distribution of employment within firms. If the number of establishments is increasing and the share of employment within HQ remains constant, this would mean that firms are fragmenting activities that are already outside the HQ. However, if the share of employment within HQ decreases over time, this would mean that firms are decentralizing activities from HQ to non-HQ locations. For this reason, we examine the evolution of the average share of workers employed at HQ and non-HQ

[11] Among our sectors, business services is the one with the largest increase in the number of firms since 1980. The expansion of this sector has also happened in other countries like the United States, where the size of the business services sector has quadrupled in 50 years, as shown by Eckert (2019).

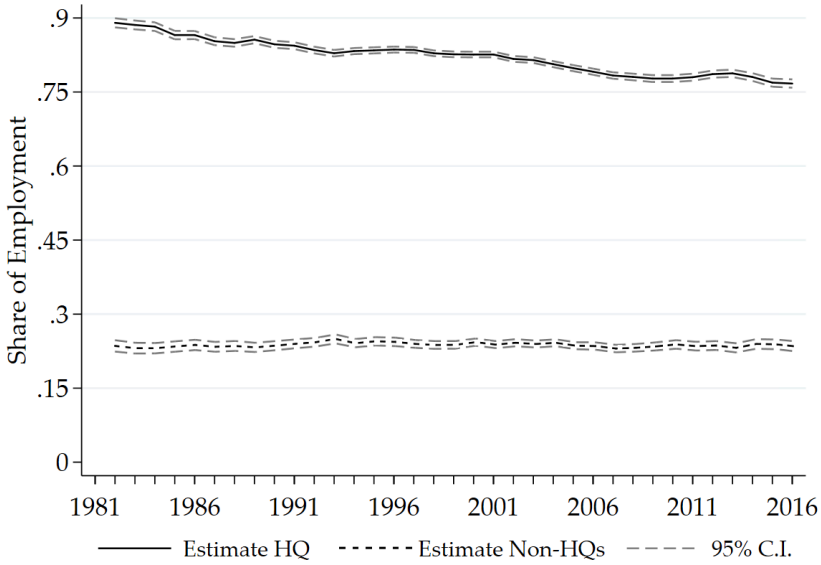
establishments by estimating the following regressions:

$$\frac{L_{HQ,t}}{L_{f,t}} = \alpha_f + \delta_t + \varepsilon_{ft}, \tag{2}$$

$$\frac{\bar{L_{i\in N,t}}}{L_{f,t}} = \alpha_f + \delta_t + \varepsilon_{ft}, \tag{3}$$

where $L_{f,t}$ denotes the total number of workers in firm f in year t, $L_{HQ,t}$ denotes the total number of workers at firm f's HQ in year t, $L_{i\in N,t}$ denotes the total number of workers in a non-HQ establishment i from firm f in time t, and $\frac{\bar{L_{i\in N,t}}}{L_{f,t}}$ the average across all firm f's non-HQ establishments. Similar to regression (1), year fixed effects from these regressions capture changes in the distribution of employment within firms and not changes in the aggregate composition of firms. We plot the estimated year fixed effects from both regressions in Figure 5.

Figure 5: Concentration of Employment across Establishments



This figure shows the evolution of the concentration of employment across establishments within firms. The solid line shows the estimated year fixed effects from a regression of each firm's average share of workers employed at HQ on year and firm fixed effects. The dashed line shows the estimated year fixed effects from a regression of the average (across non-HQ establishments within a firm) share of workers within each establishment on year and firm fixed effects. We estimate these regressions using only firms that had multiple establishments at some point between 1981 and 2016.

The results from these regressions show a decrease in the average share of workers employed at the HQs (solid line) since 1981, from 89% to 76%. Even though a reduction of 13 pp seems small, recall that firms with multiple establishments are usually large, and a small reduction in this share means that a considerable amount of jobs are relocated. In addition, notice that the average share of employment across non-HQ establishments (dotted line) has remained constant—around 23%—over this period.[12] Together with Figure 4, these results suggest that,

[12]In Figure A3, we 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.

the increase in the average number of establishments has been accompanied by an increasing decentralization of jobs out of the HQ to new 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 out from the HQ. Therefore, we investigate how establishment location and the spatial decentralization within firms have evolved over time by examining changes in the average distance between a firm's establishments and its HQ. Using the raw data, we find a sustained increase in the average distance between establishments and their HQ from 8 km in 1981 to 12 km in 2016 (50%). We show this increase in the left plot in Panel A in Figure 6.

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 firms still place most of their workforce near the HQ, while leaving few workers in those relatively far-away establishments. Therefore, we also consider the evolution of the average distance of workers from their HQ by computing a weighted average distance of establishments from their HQ, where weights are given by the relative size of each establishment within the firm. The right plot in Panel A in Figure 6 shows a 47% increase in this indicator, from 5.9 km in 1981 to 8.7 km in 2016.

Our measures of average distance include the distance of the firm's HQ to itself. By including these zeros, the baseline distances of our figures are lower, which could inflate the percentage changes. However, if we excluded the HQ from these measures, we would exclude firms that go from one to multiple establishments. In other words, we would only capture the decentralization taking place in firms that are already decentralized (i.e., that already have multiple establishment). To reconcile these points, in Panel B in Figure 6 we present the average distances of non-HQ establishments and workers to their HQ. In both cases, the levels of the changes are larger (around 50km), but the growth rates are similar to those from Panel A (around 47%).

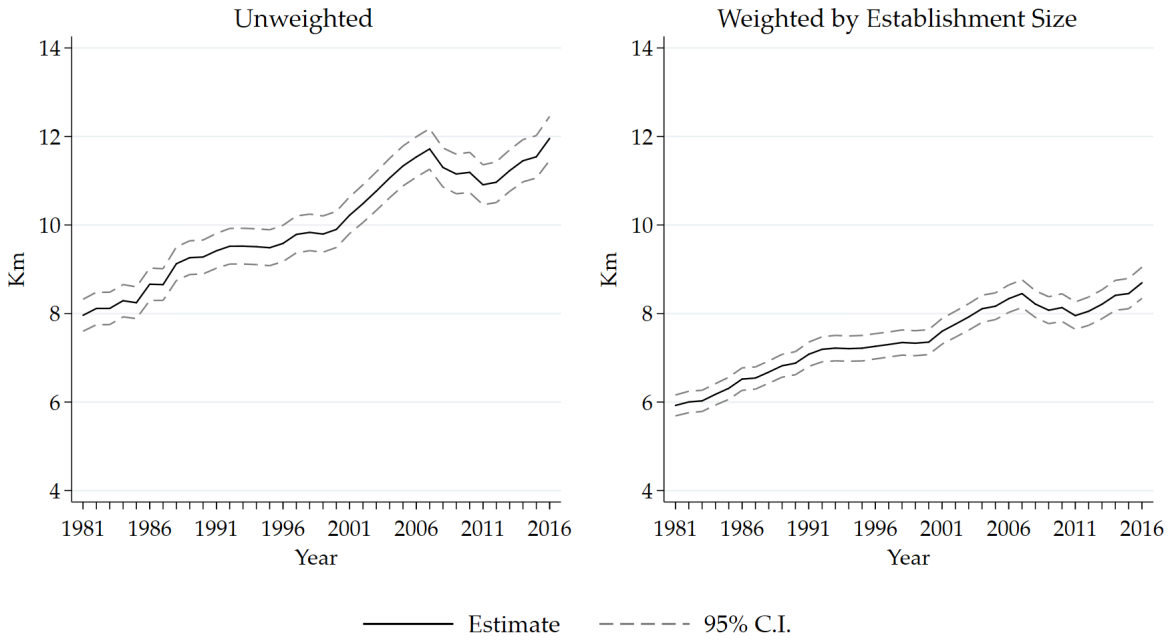
Similar to what we argued for Fact 1, the average distance between establishments and their HQ observed in the raw data can be a combination of within-firm decentralization and changes in the composition of firms (i.e., more dispersed firms entering the market or compact firms exiting). In order to capture the spatial decentralization happening within firms, we estimate the following regression:

$$\bar{D}^{u}_{ft} \quad = \quad \alpha_f + \delta_t + \varepsilon_{ft},, \tag{4}$$

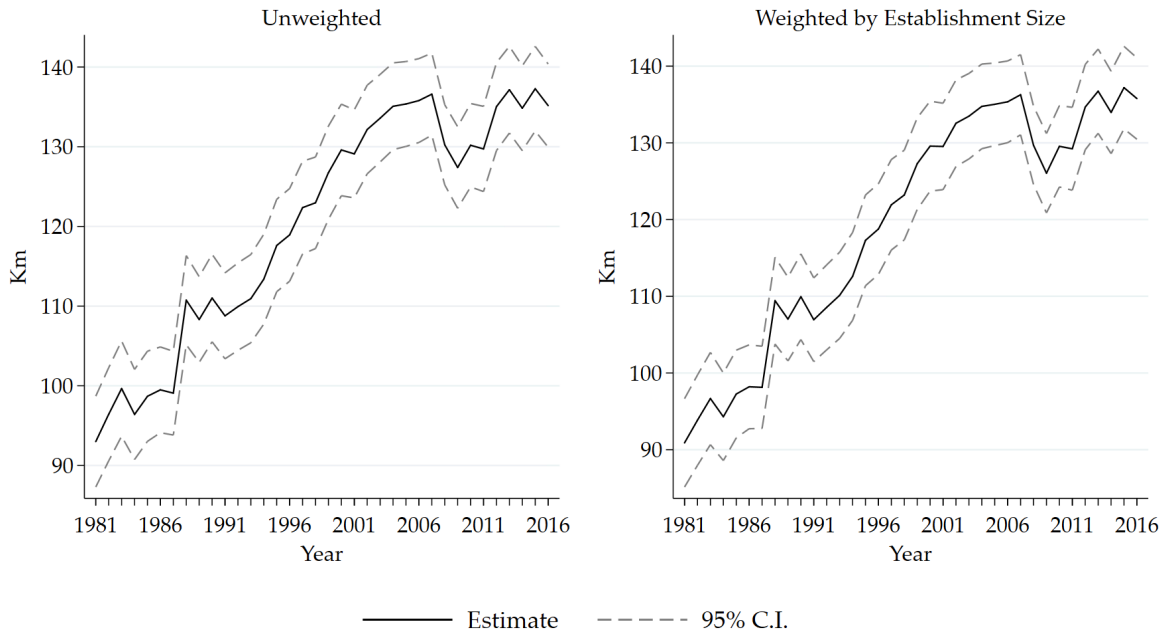
where $\bar{D}^{u}_{ft} = \frac{1}{E_{ft}} \sum_j dist_{j,HQ}$ corresponds to the average distance between a firm's establishments and their HQ, E_{ft} denotes the number of establishments of firm f in year t and $dist_{j,HQ}$ the distance of an establishment j from its HQ. In Panel A from Figure 7, we plot the estimated year fixed effects of this regression. Our estimates show a sustained increase of 108% in the

Figure 6: Average Distance between Establishments and Headquarters - Raw Data

Panel A: All Establishments



Panel B: Non-HQ Establishments



This figure shows the evolution of the average distance of establishments from their HQ coming from our raw data. In Panel A, we compute the average between all establishments, including HQ. In Panel B, we compute the same average, but only for non-HQ establishments. In the left plots, we show unweighted averages, while in the right plots, we weight each establishment by its relative size within the firm.

average distance between a firm's establishments and its HQ, relative to the 1981 mean of 6.5 km.

Note that once we control for firm fixed effects, both the levels and percentage changes in the average distance to HQ are larger compared with those from the raw data (Figure 6). 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, 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 estimate equation (4) using the average travel time between establishments and their HQ as the dependent variable.[13] In this case, the average travel time increased from 10.4 minutes in 1981 to 15.4 minutes in 2016, for a 48% increase. The left plot in Panel B in Figure 7 shows these results. This lower growth rate may be due to the fact that longer trips are usually via trains or highways with higher speed limits and less congestion than shorter journeys within urban areas.

The identification of the estimated year fixed effects from equation (4) 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 estimate equation (4) defining the dependent variable as $\bar{D}^{w}_{ft} = \sum_j dist_{j,HQ} \left(\frac{L_{jt}}{L_{ft}}\right)$, where L_{jt} is the total employment in establishment j and L_{ft} is the total employment in firm f at time t. This weighted average represents the average distance (or travel time) between workers and their firm's HQ.[14] The results from this regression show a 94% increase in the average distance of workers relative to the 1981 value of 5 km. When we use travel time, we find an increase from 9.3 to 12.7 minutes (36%). 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.[15] The graphs in the right column in Figure 7 shows these results.

To explore whether within-firm decentralization is taking place within or outside HQs' local labor markets, we decompose the evolution of the total number of establishments per firm—presented in Figure 4—between new establishments in the same traffic zone (TZ) as their HQ, in the same municipality, in the same commuting area, and in the rest of the country. Figure 8 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.[16]

[13]Recall that travel times between traffic zones are defined by the National Transport Model based on the quality, size and congestion of roads between them (Technical University of Denmark, 2017).

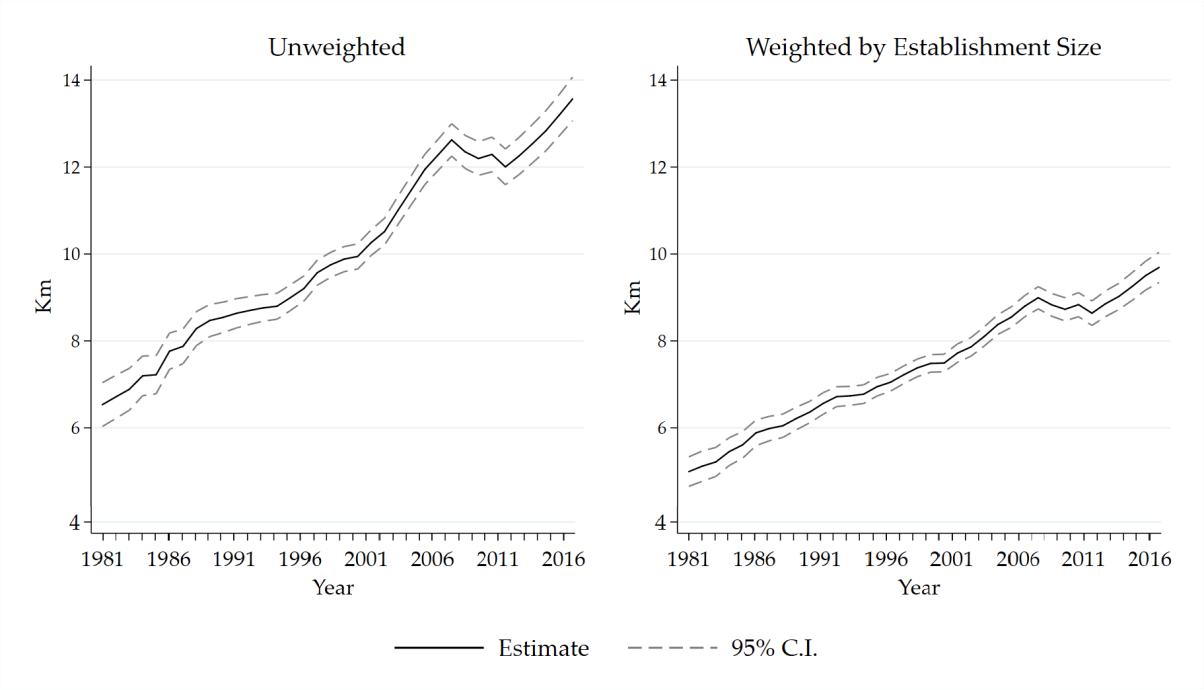
[14]This regression also helps us control for possible changes in the way Statistics Denmark defines establishments. Nevertheless, we are not aware of any relevant change in these definitions that might affect our results.

[15]We also estimate these regressions using only those firms that had multiple establishments at some point in our period. In this case, 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. Figure A4 shows these results.

[16]Panel B in Figure A1 presents the results of the decomposition using only those firms that had multiple establishments at some point during our period. The results are almost equivalent.

Figure 7: Spatial Decentralization - within Firm Variation

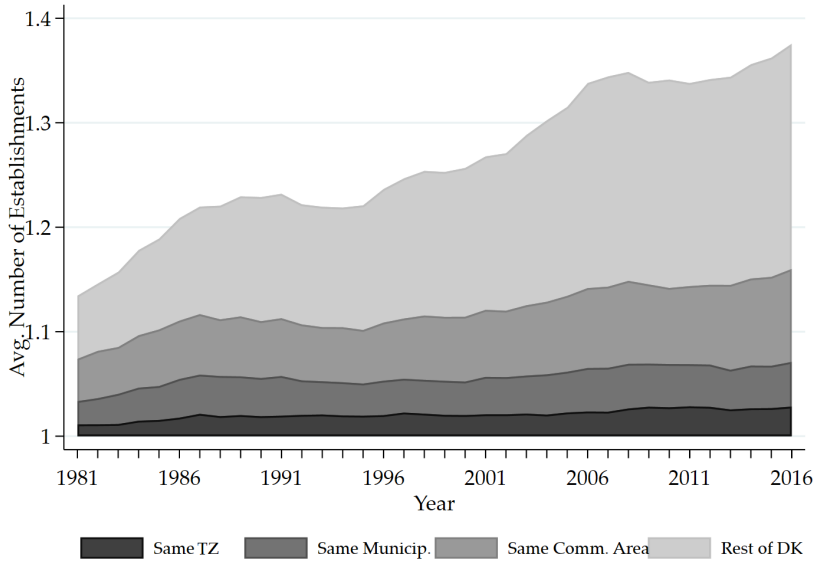
Panel A: Average Distance between Establishments and Headquarters



Panel B: Average Travel Time between Establishments and Headquarters

This figure shows the evolution of spatial decentralization within firms given by two measures: average distance between establishments and their HQ within firms (Panel A) and average travel time between establishments and their HQ within firms (Panel B). In particular, we plot the estimated year fixed effects of regressions of these two measures on firm and year fixed effects. For figures in the left panels, we use unweighted averages; for figures in the right, we use weighted averages using the establishment's relative size within the firm as weights.

Figure 8: Decomposition of the Total Number of Establishments



This figure shows the evolution of the total number of establishments within firms computed as the estimated year fixed effects from a regression of each firm's total number of establishments on year and firm fixed effects, separating between 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 about doubled between 1980 and 2016. This increase primarily comes from the opening of new establishments outside the HQ's commuting area.*

The measures of average distance used in the previous figures is influenced equally by establishments close to and far from the HQ. For example, if a firm has a non-HQ 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 A5 shows that the average maximum distance to HQ increased from 9.8 to 24.4 km (a 148% increase).[17]

We also examine changes in the average distance to HQ for our four aggregate sectors. 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 this sector facing higher fixed and fragmentation costs (communication and shipping). When we weight by establishment size, we see an increase

[17]When we consider only firms that had multiple establishments during our period, this measure increases from 47 to 103 km (119%).

of 3 km for manufacturing (54%), 5.8 km for transportation (121%), and 8.2 km for business services (307%). We present these results in Figures A6 and A7.

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 revealed among the different occupations within firms or whether it has been a general phenomenon. We start by investigating the evolution of the average distance to HQ of workers in each occupation category by estimating a modified version of equation (4) for each of them:

$$\bar{D}^o_{ft} \quad = \quad \alpha_f + \delta_t + \varepsilon_{oft},, \tag{5}$$

where $\bar{D}^o_{ft} = \sum_j dist_{j,HQ} \left(\frac{L_{ojt}}{L_{oft}}\right)$, L^o_{jt} denotes the total employment of workers in occupation o in establishment j and L^o_{ft} the total employment of workers in occupation o in firm f at time t. We plot the estimated year fixed effects of these regressions in Figure 9.

Our results indicate that all occupational categories experienced a similar increase in their average distance to HQ of around 70% between 1991 and 2016.[18] However, when we examine the estimates closely, a ranking of occupations with respect to changes in their distance to the HQ appears. Workers in business services, and engineering and science occupations experienced the largest decentralization, followed by production and clerical workers, and managers. These results suggest that firms are currently locating managers and clerical workers close to their HQ, relative to workers in other occupations.[19]

We also explore these changes in distance only for non-HQ establishments. That is, excluding the HQ from our measures. In this case, workers in managerial, business services, and engineering occupations experience a larger increase in their distance to HQ compared with production and clerical workers. These results complement the previous in two ways. First, without taking into account workers at the HQ, firms are increasingly locating high-skilled jobs in establishments seemingly far from the HQ and, probably, closer to other locations in which they can exploit comparative advantages (e.g., larger cities, universities, transportation hubs, etc.). Second, even though production and clerical occupations are far from the HQ (between 120 km and 130 km away), ME firms are not moving these activities much farther within the country. We present these results in Figure A9.

These results point the existence of strong complementarities within establishments. Specifically, firms could obtain productivity gains by locating some particular occupations together. For example, concentrating managers at the HQ, or colocating business services and engineering activities. The sharp reductions in communication costs that resulted from the expansion of

[18] These figures start in 1991, which is the first year for which we have data on occupational classification.

[19] Using similar regressions, we investigate the evolution of the share of employment at HQ for each occupational category within firms. In this case, production and clerical workers experienced the largest decrease—8 and 6.7 pp, respectively—while the decrease for business services, engineering, and managerial occupations is less sharp: 6, 4.9, and 3.9 pp, respectively. Figure A8 shows these changes.

Figure 9: Average Distance to the HQ by Occupation - within Firm Variation

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

broadband potentially contributed to these patterns. If communication between establishments is relatively easier, firms can seek a more efficient allocation of their activities across locations.

Since the six occupational groups we use are exhaustive, the sum of the average distance to HQ of workers in each occupation should equal the firm-level measure from equation (4), given some weights. This aggregation implies that we can study the contribution of each occupation to the total change shown in Figure 7. For this purpose, we write the average distance of firm f's workers to their HQ at time t ($\bar{D}^w_{ft}$) as:

$$\begin{aligned} \bar{D}^w_{ft} &\equiv \sum_j dist_{j,HQ}\left(\frac{L_{jt}}{L_{ft}}\right) \\ &= \sum_j dist_{j,HQ}\left(\frac{\sum_o L_{ojt}}{L_{ft}}\right) \\ &= \sum_o \frac{L_{oft}}{L_{ft}}\left[\sum_j dist_{j,HQ}\left(\frac{L_{ojt}}{L_{oft}}\right)\right] \equiv \sum_o \frac{L_{oft}}{L_{ft}}\bar{D}^o_{ft}, \end{aligned} \tag{6}$$

where the first equality is given by the definition of $\bar{D}^w_{ft}$ given in Section 3.2, and the last one by the definition of $\bar{D}^o_{ft}$ from equation (5); $\frac{L_{oft}}{L_{ft}}$ is the share of workers in occupation o within firm f at time t, and $\frac{L_{ojt}}{L_{oft}}$ is the share of workers in occupation o and establishment j relative to the total inside the firm. Notice from the last expression that, the average distance of firm f's workers from their HQ can be decomposed between the relative use of each occupation within the firm ($\frac{L_{oft}}{L_{ft}}$) and their respective average distance to HQ ($\bar{D}^o_{ft}$). Therefore, the change in the average distance of firm f's workers from their HQ can also be decomposed between the changes in these two factors for each occupation. We show the results of this decomposition in Table 1 and present its technical details in Appendix B.3.

Our decomposition shows that workers in business services, engineering and sciences, and production occupations respectively contribute by 33.5%, 29%, and 27% to the observed change of the average distance of workers to their HQ. Clerical workers contribute by 6.81% to this change, and managers by around 10%. Nevertheless, the contribution of each occupational category comes from different sources. For managers, 60% of their contribution comes from an increase in their use within firms. In fact, between 1991 and 2016, managers went from being 4.9% of the total number of workers within firms to 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 strong reduction in the use of these occupations that contributes negatively to the total change, by 9.4%. For production workers, all of their contribution to the total change comes from a movement of production tasks away from the HQ. Decentralization of engineers and workers in the science professions accounts for one-fourth of the total observed change. 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 significant expansions of the tech and communications sectors.

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%
Production		27.03%
Change in Distance		28.01%
Change in Use		-0.98%
Business Services		33.54%
Change in Distance		16.84%
Change in Use		16.70%
Engineers & Scientists		29.12%
Change in Distance		24.33%
Change in Use		4.78%
Clerical		6.81%
Change in Distance		16.19%
Change in Use		-9.38%
Others		-6.31%
Change in Distance		2.44%
Change in Use		-8.74%

This table shows the decomposition of the total change in the distance between workers and their HQ within firms into changes in the use and the average distance of six occupational categories. The percentages add up to 100% and not to the observed change. This decomposition is described in Equation (7).

Lastly, changes in the location of workers in 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 is just as important as the increase in their average distance to the HQ. Moreover, the data suggest that firms are replacing clerical workers by business services workers. Two possible reasons are behind these changes. First, business services firms and workers have become more important in recent decades in Denmark. Second, this has probably caused a higher competition for office space and workers, thereby promoting the relocation of business services to other municipalities for cost-saving reasons.[20]

Based on these findings, we formulate a third fact:

FACT 3: *Most of the spatial decentralization within firms comes from (i) a decentralization of production, engineering and business services workers; along with (ii) a replacement of clerical workers by business services workers.*

[20]This second mechanism is proposed by Liao (2012) who argues that the relocation of business services has gotten easier due to improvements in communications technology.

Following equation (7), we can also decompose the changes in the relative use of each occupation into their changes at HQ, at establishments relatively close to the HQ and at establishments relatively far from the HQ. We show the results of this extended decomposition in Table A3. Three results are worth highlighting from this decomposition. First, most of the increase in the relative use of managers comes from increases within HQ. Second, there has been a movement of production jobs from the HQ to non-HQ establishments, which is consistent with the patterns presented above. Third, firms have increased the use of engineers and scientists both at HQ and in locations relatively farther away. This last finding is consistent with firms' desire to locate these jobs inside the HQ or in municipalities with a relatively high concentration of universities and R&D centers, even if they are far from the HQ.

3.4 More Managers per Worker

In the previous decomposition, we found important changes in the use and location of managers, production and clerical workers across establishments between 1991 and 2016. These trends imply that the ratio of managers to production and clerical workers—within firms and establishments—might have changed during the same period. This, in turn, could reflect significant changes in the composition of production teams. In this last subsection, we explore the evolution of this ratio within firms and establishments between 1991 and 2016. We start by estimating the regression:

$$\left(\frac{M}{P+C}\right)_{ft} = \alpha_f + \delta_t + \varepsilon_{ft}, \tag{7}$$

where $\left(\frac{M}{P+C}\right)_{ft}$ denotes the ratio of managers to production and clerical workers for each firm f in time t, α_f denote firm fixed effects, and δ_t year fixed effects.

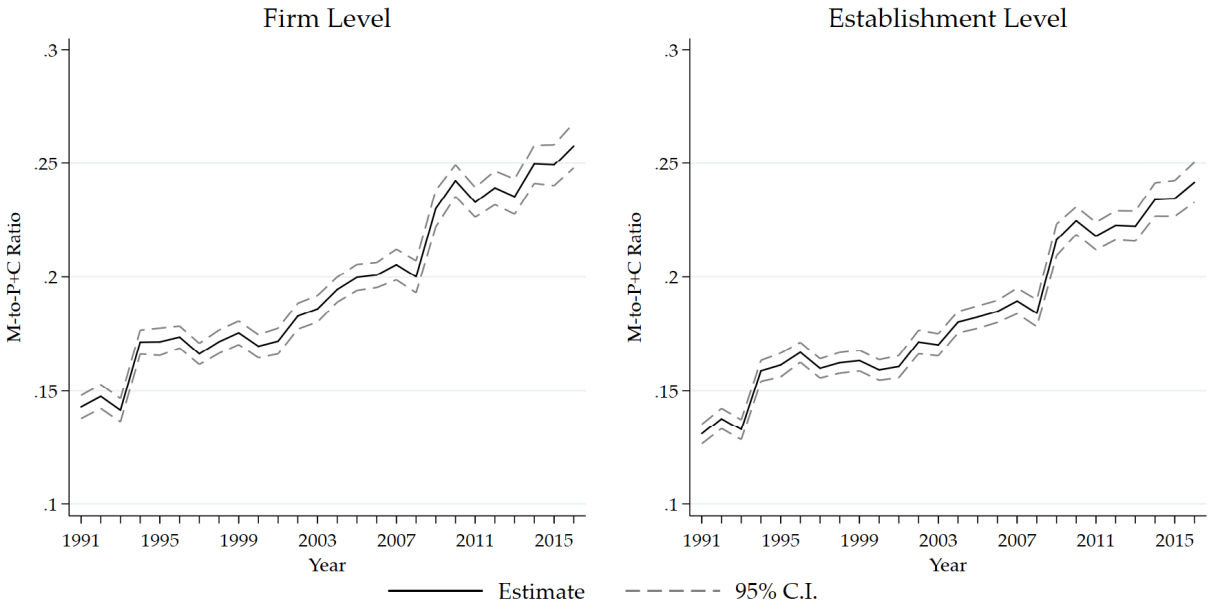
The estimated year fixed effects from equation (7) show a clear upward trend of this ratio since 1991, going from approximately 0.14 to around 0.26 in 2016, for a 80% increase. The left graph in Figure 10 shows these results, which are stronger when we estimate the same regression at the establishment level. Specifically, the right plot in Figure 10 shows that in the average establishment, this ratio went from approximately 0.11 to around 0.24, for a 112% increase.

The increase in this ratio could be interpreted as a reduction in the span of control within firms, since it shows a reduction in the number of workers per manager.[21] However, two other phenomena could be behind the increase in this ratio. First, as our results from Table 1 suggest, firms may be replacing production and clerical workers for workers in other occupations, such as in the business services. Second, firms may be dividing their employees into more layers, populated by more skilled workers, such as engineers or scientists.[22] To explore these possibilities, we perform two exercises. For the first case, we include in the denominator of the

[21] This ratio has been widely use in the literature as a measure of span of control. For examples, see Lucas (1978), or Garicano and Rossi-Hansberg (2006).

[22] See Spanos (2019) or Caliendo et al. (2015) for recent examples of papers studying the internal organization of labor within firms into hierarchical layers based on their occupations and job complexity.

Figure 10: Ratio of Managers to Production and Clerical Workers - within Firm Variation



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).

ratio, not only production and clerical workers, but also business services workers. In this case, we find that the ratio has gone from approximately 0.11 to 0.16 in 2016 (for a 44% increase). For the second case, we include in the denominator all non-managerial occupations. In this case, the ratio increases by 27%, going from 0.9 to around 0.12 in 2016. We show these results in Figure 11. These numbers suggest that, the increase in the number of managers per worker is robust regardless on how we define the latter group.

The increase in the manager-to-worker ratio presented in Figure 10 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 estimate the following regression at the establishment-level:

$$\left(\frac{M}{P+C}\right)_{jft} = \alpha_j + \delta_t + \beta_t \mathbf{1}_{\{j,HQ\}} + \varepsilon_{jft}, \tag{8}$$

where $\mathbf{1}_{\{j,HQ\}}$ is an indicator variable that equals 1 when establishment j is a HQ, which we multiply times year fixed effects β_t. We present the results from this regression in Figure 12, where we plot the estimated year fixed effects, separating between HQ and non-HQ establishments. Both graphs show that the number of managers per worker was quite similar in 1991 and has increased in both types of establishments. However, the increase has been much larger in HQ establishments, going from 0.12 in 1991 to 0.4 in 2016 (a 143% increase), while in non-HQ establishments it went from 0.11 in 1991 to 0.19 in 2016 (a 69% increase).

Regarding establishment location, we examine the evolution of the ratio in establishments

Figure 11: Ratio of Managers to Workers - within Firm Variation - Other Definitions

This figure shows the estimated year fixed effects from a regression of each firm's ratio of managers to production, clerical and business services workers (Panel A), or the ratio of managers to production, clerical, business services and engineering workers (Panel B), on year and firm fixed effects.

located in Denmark's two main urban areas and the rest of the country by estimating the following regression:

$$\left(\frac{M}{P+C}\right)_{jft} = \alpha_j + \delta_{c,t}\mathbf{1}_{\{j,CPH\}} + \delta_{a,t}\mathbf{1}_{\{j,Aarhus\}} + \delta_{a,t}\mathbf{1}_{\{j,Rest\}} + \varepsilon_{jft}, \tag{9}$$

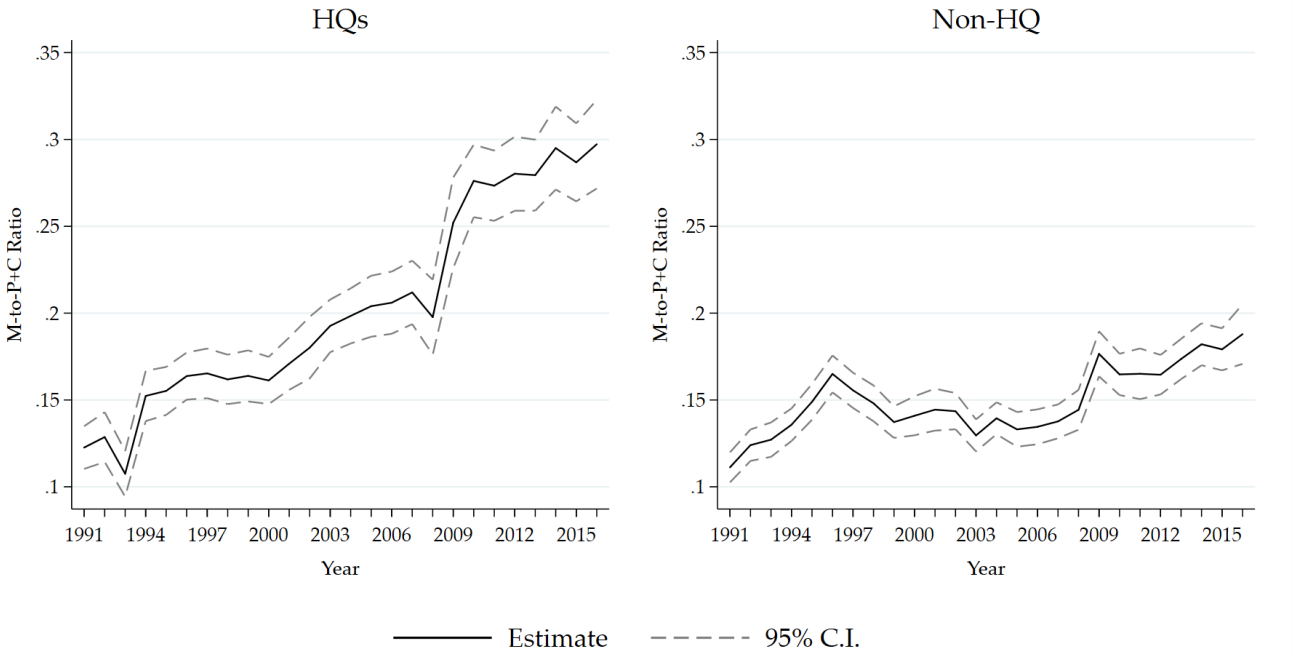
where $\mathbf{1}_{\{j,X\}}$ is an indicator function that equals 1 if establishment j is located in $X \in \{CPH, Aarhus, Rest\}$, and CPH denotes Copenhagen metropolitan area. . Estimates from this regression show that the increase in the number of managers per worker observed at the firm level comes mainly from establishments located in Copenhagen and Aarhus. More specifically, we observe an increase of 169% in the ratio for establishments in Copenhagen, of 181% for establishments in Aarhus, and of 60% in the rest of the country. Figure 13 shows these estimates.[23]

In Figure A11, we present the evolution of the ratio of managers to production and clerical workers inside firms and 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 from Figures 10 and 12, but the increase in the number of managers per worker is larger. This difference suggests that new establishments (either new SE firms or new from existing ME firms) have relatively

[23]In Figure A10 we further show that the correlation between this managerial ratio and the log size of the municipality has increased from zero in 1991 to around 0.035 in 2016. This last correlation implies that, when comparing a municipality with one three times larger, the larger municipality has establishments with an average manager-to-worker ratio 0.1 points larger. The relatively large increase in the number of managers per worker in larger urban areas lies in line with recent evidence for the US in Santamaria (2019).

Figure 12: Managers to Production and Clerical Workers

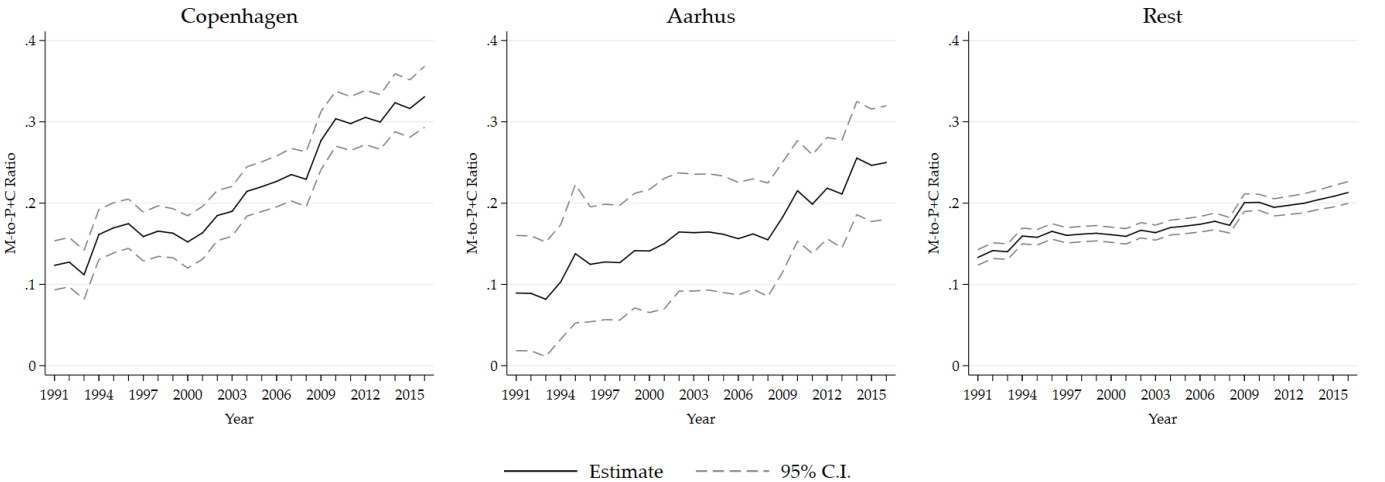
HQ vs. non HQ Establishments - Within Establishment Variation



This figure shows the estimated year fixed effects of a regression of each establishment's ratio of managers to production and clerical workers on establishment and year fixed effects, and an interaction between year fixed effects and a HQ-indicator.

Figure 13: Managers to Production and Clerical Workers by Municipality

Within Establishment Variation



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

more managers per worker compared to existing establishments.

We summarize these findings in our fourth fact:

FACT 4: *The number of managers per worker within firms increased by 80% between 1991 and 2016. Most of this change is accounted by increases within HQ establishments and establishments located in the largest cities.*

Finally, we explore whether our results can account for the evolution of the aggregate specialization patterns observed in the data, as Duranton and Puga (2005) suggest. In particular, they argue that increasing firm fragmentation could be leading to a decrease in sectoral specialization across 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. This ratio increased during this period for 91 out of the 98 municipalities in the country. Moreover, at the beginning of the 1990s, municipalities were not too different in terms of this ratio, but since then it has increased substantially for Copenhagen, its metropolitan area, and the other main urban areas. This ratio has also increased in the Triangle Region (*Trekantomraadet*), which is a group of 7 municipalities in North Jutland with a relatively high concentration of large and high productive firms and high-skilled-high-income workers. We present these changes in Figure 14, while Figure A12 shows the levels of this ratio for both 1991 and 2016.

We decompose these changes into changes in the ratio within SE firms, within establishments belonging to ME firms, and entry and exit of establishments. For the whole country, we find that increases in the average ratio of managers to production and clerical workers within ME firms accounts for 71% of the nationwide increase in this ratio.[24] At the municipality level, we find that increases in the average ratio within ME firms is the main contributor to the growth of this ratio in 35 out of 98 municipalities. Moreover, the opening of establishments belonging to ME firms is the main contributor in 15 municipalities. Therefore, increases in the ratio of managers-to-workers inside ME firms and within firm fragmentation of such firms accounts for the reduction in the number of managers per worker in more than half of the country's municipalities.[25]

4 Conclusions

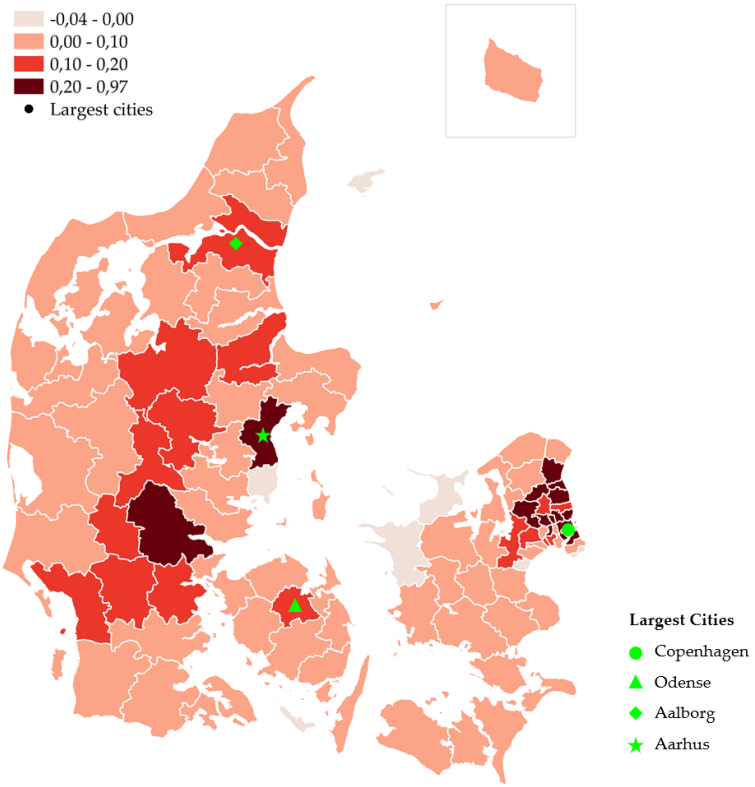
This paper studies the internal spatial organization of firms and its evolution over nearly four decades. Consistent with intuition, we find that firms have become more spatially dispersed and their geographic span of control has broaden. However, this fragmentation is not universal across firm's activities.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

[24] Increases in the average ratio within SE firms accounts for 36%, while changes in the composition of firms and net entry explain -4.6% and -2.3%, respectively.

[25] This share is even larger in the capital region (*Hovedstaden*), with 19 out of 32 municipalities (60%).

Figure 14: 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. The circle, star, diamond and triangle denote the location of Copenhagen, Aarhus, Aalborg and Odense, respectively.

a spatial decentralization of production and business services activities.

Using detailed administrative data covering the universe of firms, establishments, and workers between 1981 and 2016 in Denmark we document four stylized facts. First, 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, particularly outside their labor market areas. Third, most of the spatial decentralization within firms comes from (i) a large decentralization of production, engineering and business services workers; along with (ii) a replacement of clerical workers by business services workers. Fourth, the number of managers to production and clerical workers within firms increased by 80%, going from approximately 0.14 to 0.26. This increase comes mainly by a large increase in this ratio inside HQ 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 lo-

cate 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 affect activities such as monitoring and coordination, which are critical in the design of incentive contracts. As this paper shows, the share of ME 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 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 generate incentives for fragmentation that lowers 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

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	4	4		A1		8		8		8		8
	(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 - Only non-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	6	6	7	7			7	7	6	6		
	(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		A3		A3		A3				5		5
	(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)	(55)	(56)		
				Managers to P+C Ratio					**Include BS**	**Include BS+ES**		
	Firm Level		Establishment Level		Est. - Main Municip.		HQ and non-HQ Est.		Firm Level			
N	464,384	464,384	582,687	582,687	582,687	582,687	582,687	582,687	464,384	464,384		
R2	0.007	0.005	0.006	0.005	0.022	0.007	0.012	0.006	0.003	0.001		
Firm FE	NO	YES	NO	YES	NO	YES	NO	YES	YES	YES		
Establ.		50,917		67,032		67,032		67,032	52,044	52,644		
Figure	A11	10	A11	10		13	A11	12	11	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. The complete regression results are available on request.

Table A3: Changes in Average Distance of Workers to HQ, 1991-2016

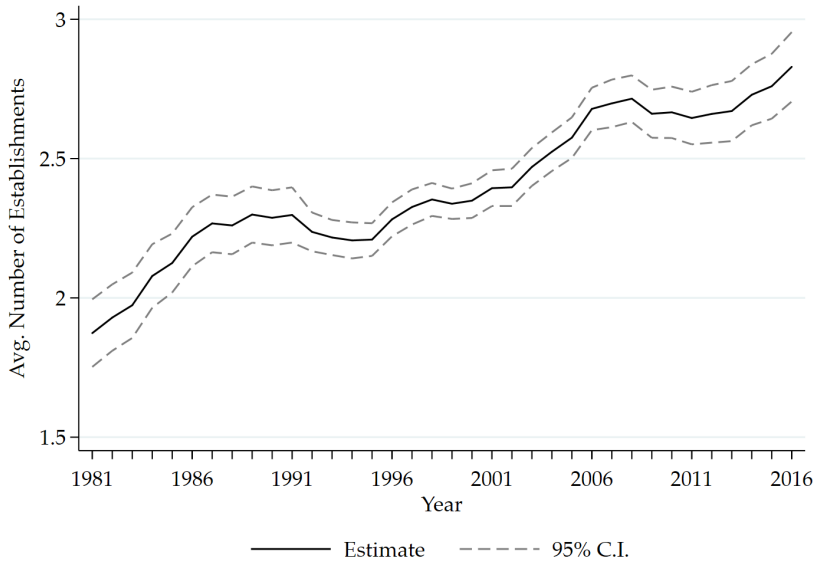
Value 1991	**Value 2016**	**Change**
6.43 km	9.40 km	46.07%
Managers		9.81%
Change in Distance		4.02%
Change in Use		5.79%
Change in Use HQ		5.43%
Change in Use Close Est		0.10%
Change in Use Far Est		0.26%
Production		27.03%
Change in Distance		28.01%
Change in Use		-0.98%
Change in Use HQ		-3.13%
Change 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. 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 (7).

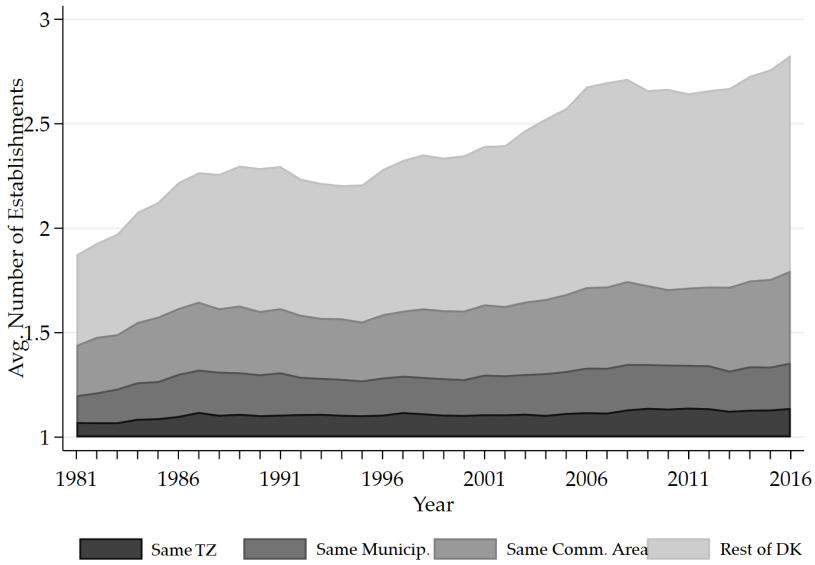
Figure A1: Average Number of Establishments - within Firm Variation

Multi-Establishment Firms

Panel A: Evolution

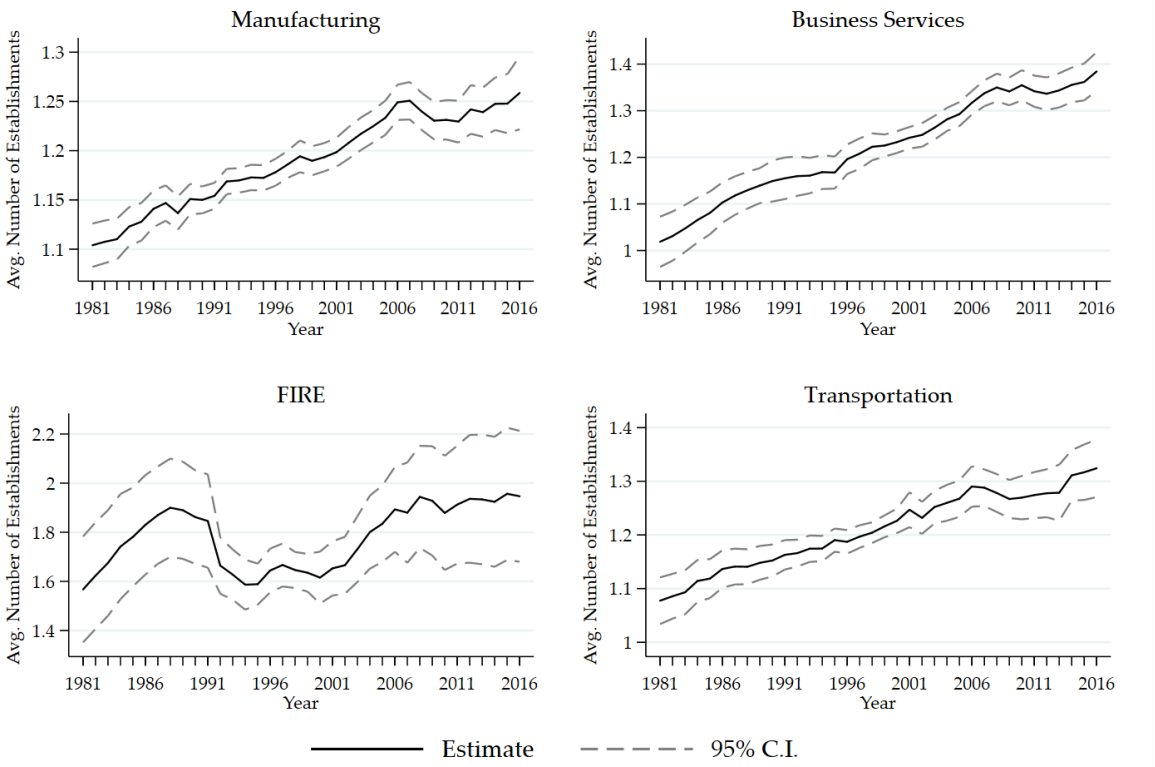


Panel B: Decomposition



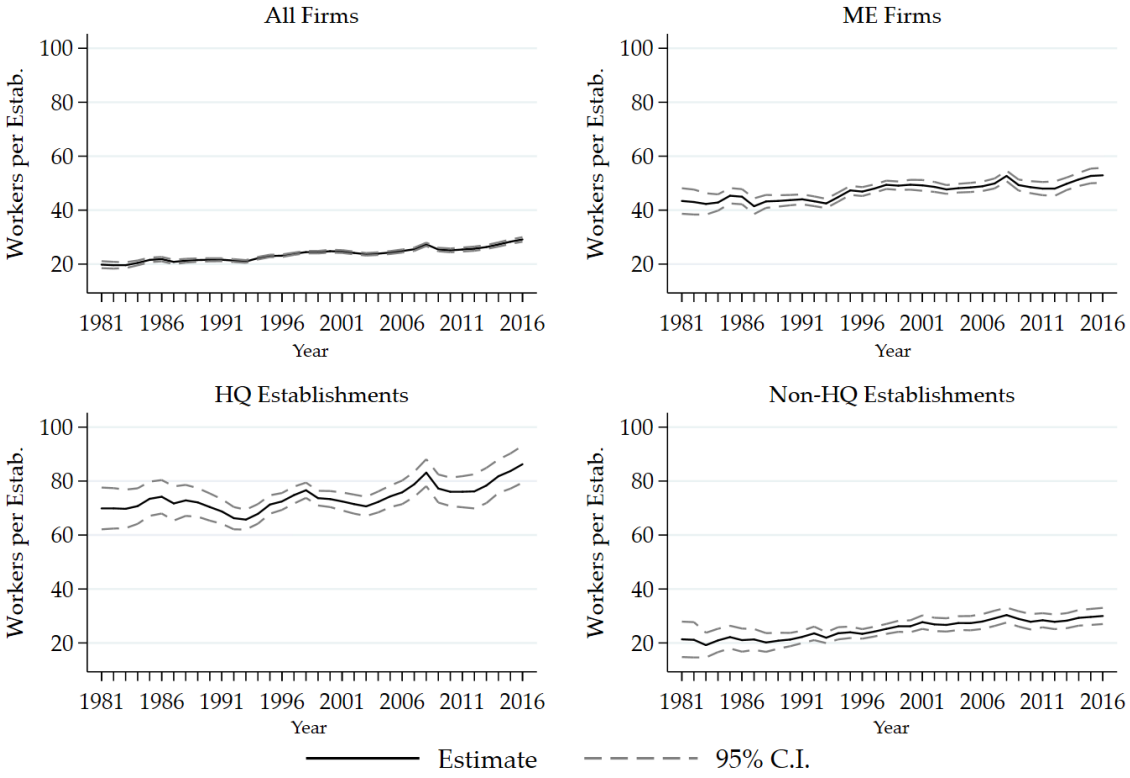
Panel A in this figure shows the estimated year fixed effects from a regression of each firm's total number of establishments on year and firm fixed effects, using only firms that had multiple establishments at some point between 1981 and 2016. Panel B shows the evolution of the total number of establishments 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 A2: Evolution of the Total Number of Establishments - within Firm Variation



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 A3: Evolution of the Average Establishment Size - within Firm Variation



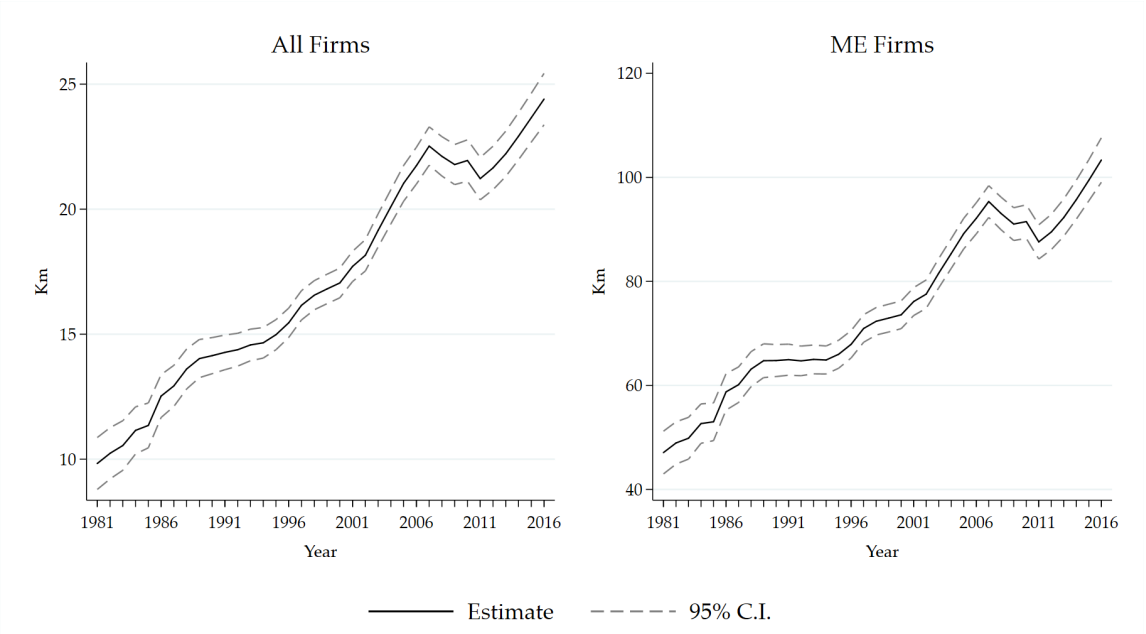
This figure shows the estimated year fixed effects from a regression of each firm's average number of workers per establishment type (all, HQ, or non-HQ) on year and firm fixed effects.

Figure A4: Average Distance between Establishments and HQ

for Multi-establishment Firms - within Firm Variation

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.

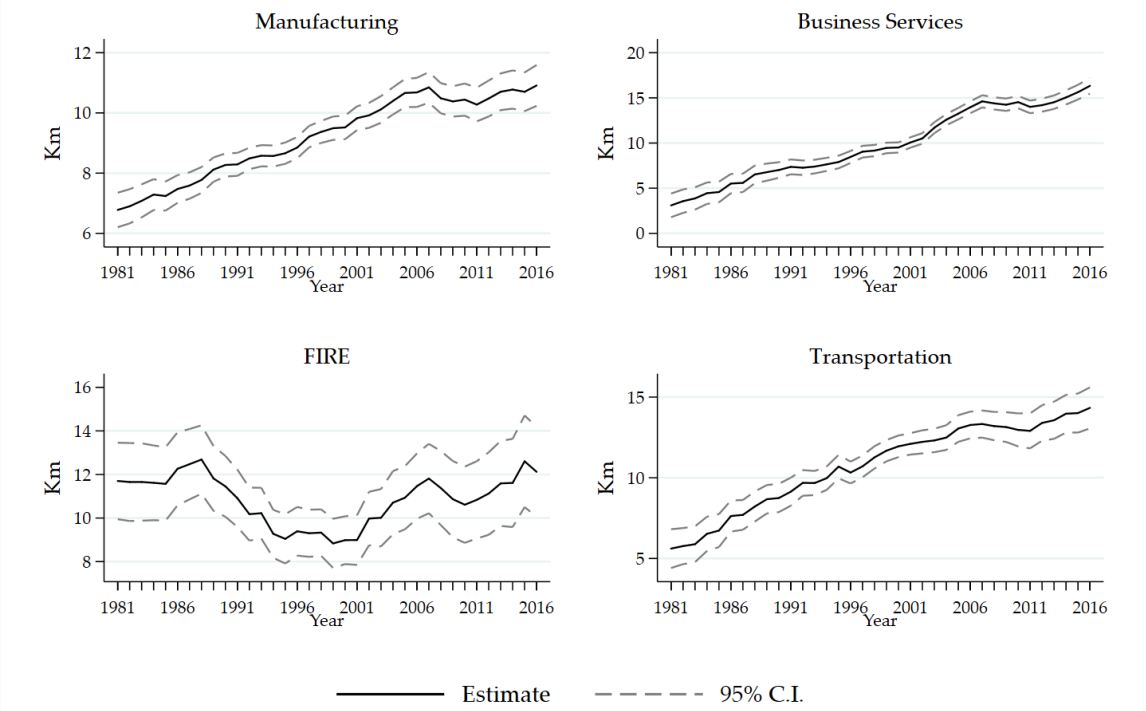
Figure A5: Maximum Distance between Establishments and HQ - within Firm Variation



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 A6: Average Distance between Establishments and Headquarters by Sectors

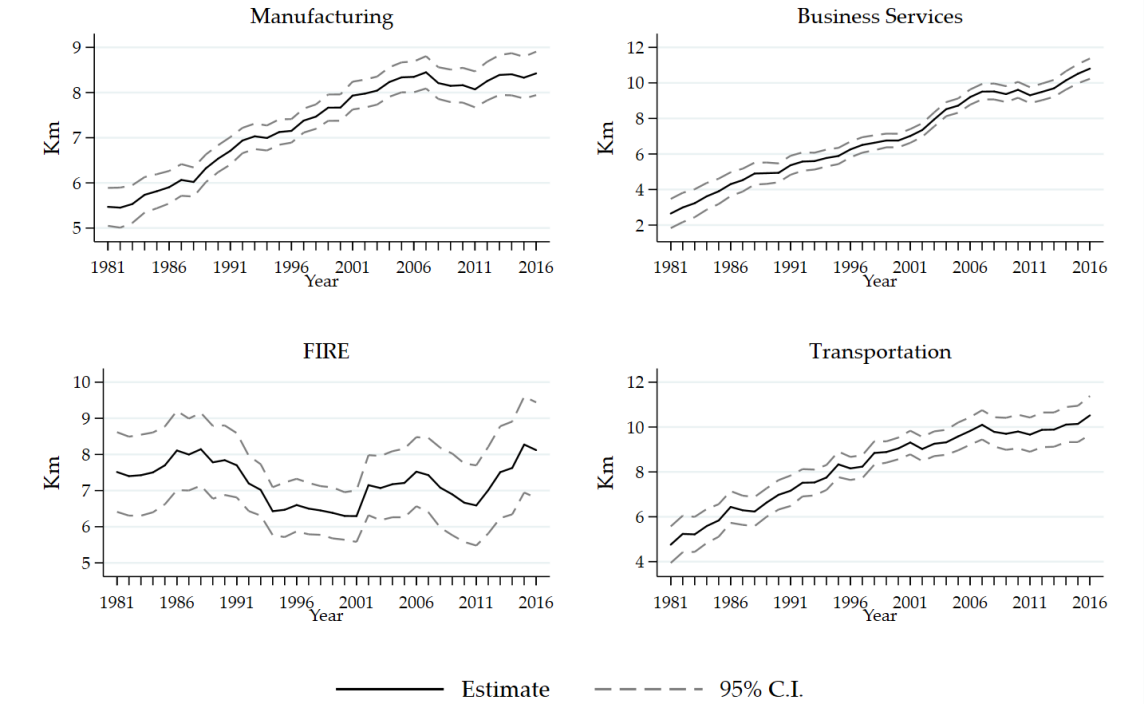
Unweighted - within Firm Variation



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 A7: Average Distance between Establishments and Headquarters by Sectors

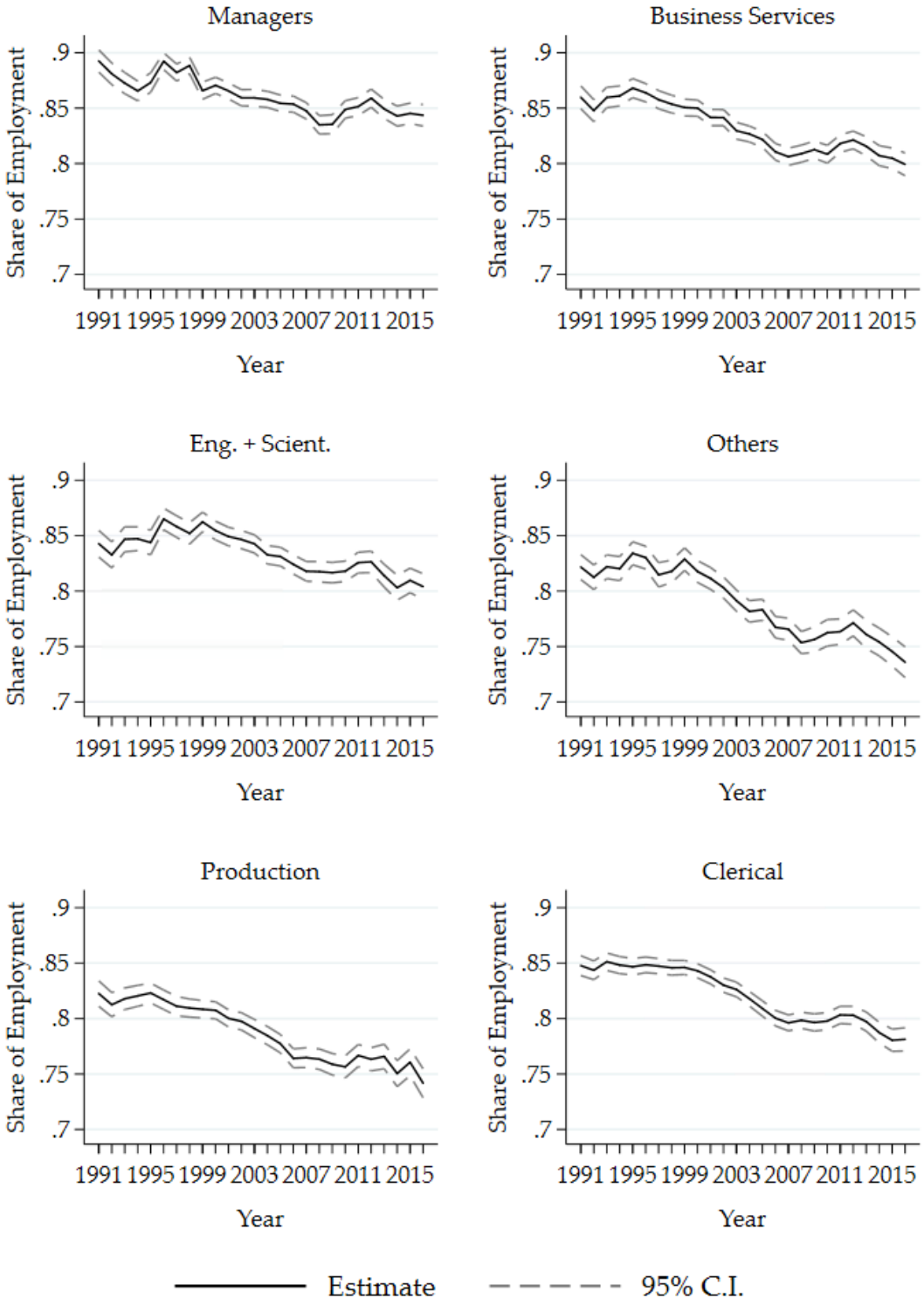
Weighted by Number of Workers - within Firm Variation



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 A8: Concentration of Employment at the HQ by Occupation

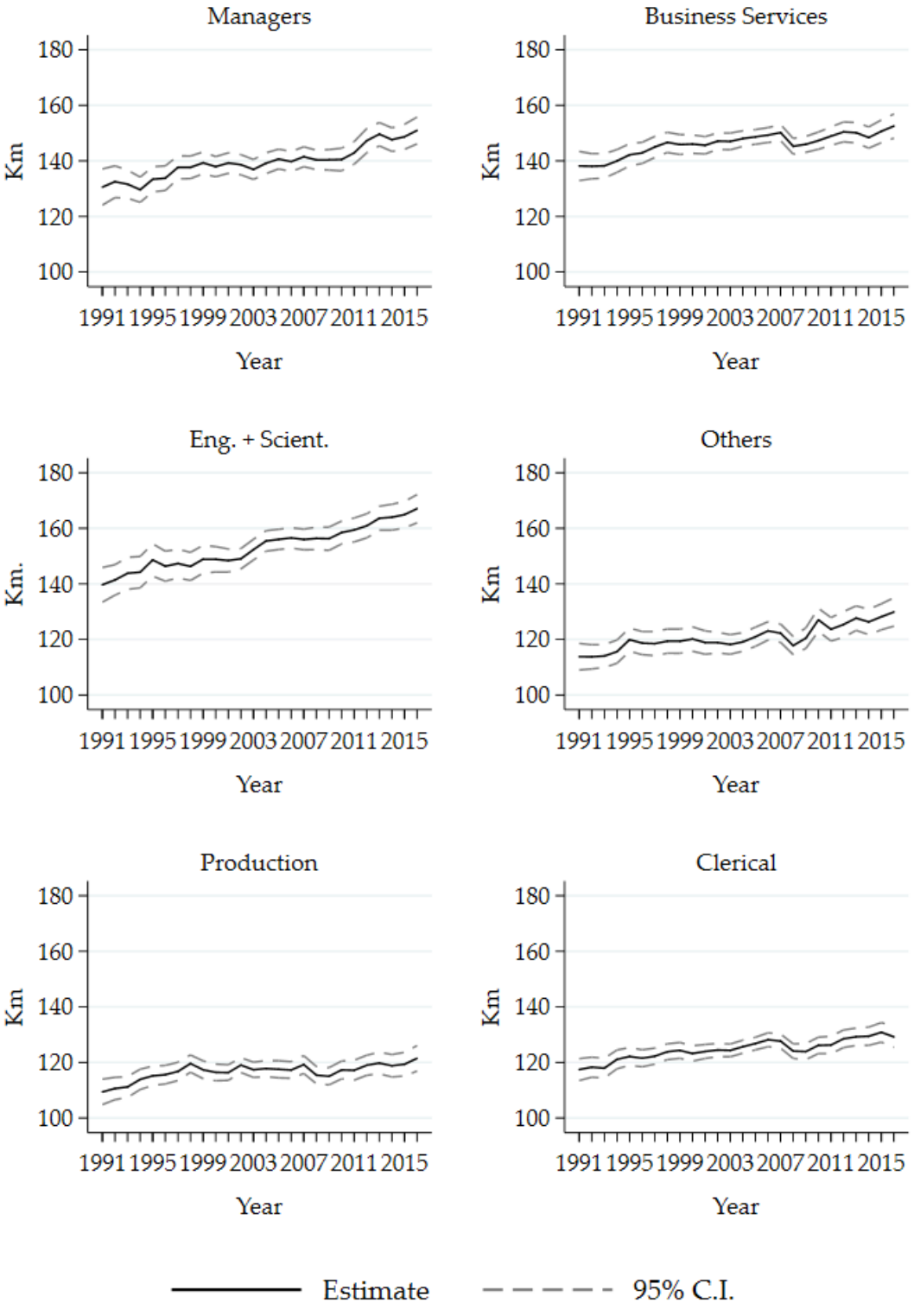
within Firm Variation



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.

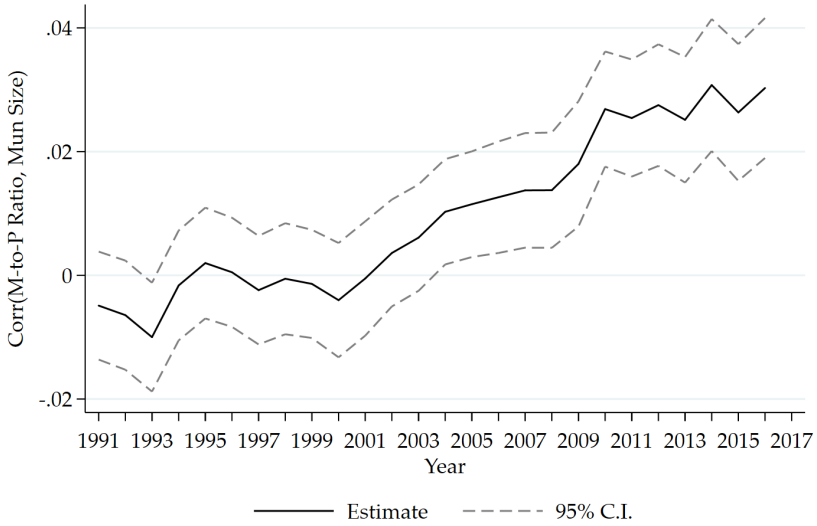
Figure A9: Average Distance to the HQ by Occupation - Only non-HQ

within Firm Variation



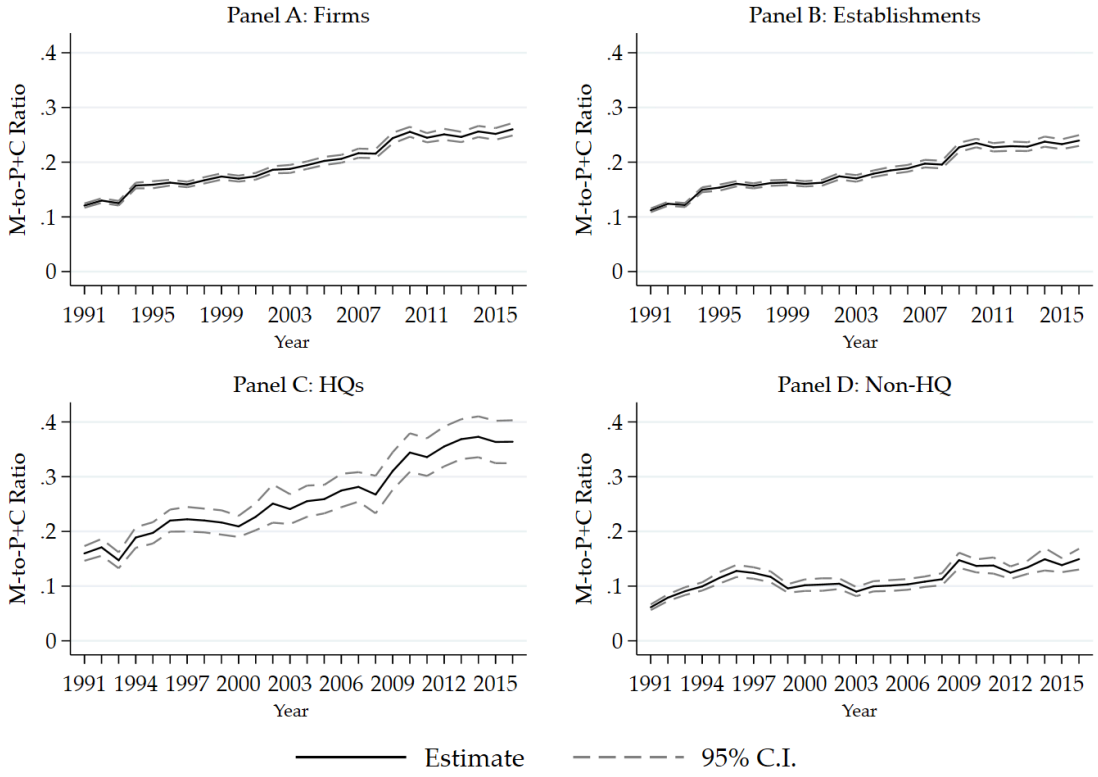
This figure shows the estimated year fixed effects of a regression of each firm's average distance of non-HQ establishments to their HQ (weighted by the establishment's relative number of employees within each occupation category) on year and firm fixed effects.

Figure A10: Managers to Production and Clerical Workers and Municipality Size within Establishment Variation



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.

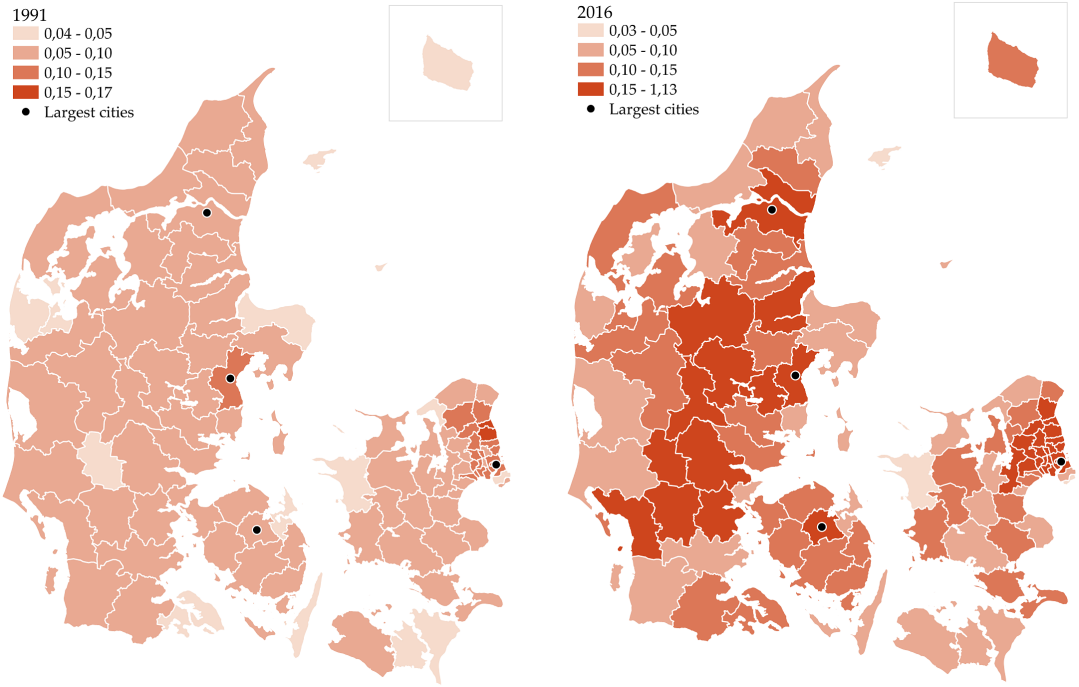
Figure A11: Managers to Production and Clerical Workers - Raw Data



This figure shows the evolution of the average ratio of managers to production and clerical workers (M-to-P+C) coming from our raw data. Panel A plots the average across firms. Panel B plots the average across establishments. Panels C and D plot the average for only HQ and non-HQ establishments, respectively.

Figure A12: 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 our data selection criteria.

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 A4: 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

After merging the various data 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. These criteria mitigate a potential data-coding problem in 1987, in which we observe an unexplained spike in the number of establishments. 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 A5 presents in detail 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. 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).

B.3 Functional Specialization: Decomposition

For the decomposition presented in Table 1, we start by defining the average distance between a firm's workers and its HQ as:

$$\bar{D}^{w}_{ft} = \sum_{j} dist_{j,HQ} \left(\frac{L_{jt}}{L_{ft}} \right) = \sum_{j} dist_{j,HQ} \left(\frac{\sum_{o} L_{ojt}}{L_{ft}} \right),$$

where o denotes an occupation and the second equality comes naturally since $L_{jt} = \sum_{o} L_{ojt}$. 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

$$\bar{D}^{w}_{ft} = \sum_{o} \frac{L_{oft}}{L_{ft}} \left[\sum_{j} dist_{j,HQ} \left(\frac{L_{ojt}}{L_{oft}} \right) \right] \equiv \sum_{o} \frac{L_{oft}}{L_{ft}} \bar{D}^{o}_{ft}, \tag{A1}$$

as presented by equation (7) in the text. Define $\bar{C}^{o}_{ft} \equiv \frac{L_{oft}}{L_{ft}} \bar{D}^{o}_{ft}$. In order to obtain the contribution of each occupational category to the average distance of workers to the HQ, we estimate the following regression for each occupation o:

$$\bar{C}^{o}_{ft} = \alpha_f + \delta^{o}_{dec,t} + \varepsilon_{ft}.$$

Table A5: 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,	31,895,266	2,098,456	1,712,395
business services, and FIRE	(52.85%)	(37.16%)	(35.47%)
Totals after dropping:			
Establishments with no location	31,429,892	2,039,947	1,682,649
or in small municipalities	(52.08%)	(36.13%)	(34.86%)
Establishments that only lived one year	31,314,545	2,015,230	1,662,871
	(51.89%)	(35.69%)	(34.45%)
Firms that had fewer than 4 employees for	28,970,535	1,086,685	741,554
more than 66% of their lives	(48.01%)	(19.25%)	(15.36%)
Establishments with fewer than 3 workers	28,792,656	964,269	689,462
	(47.71%)	(17.08%)	(14.28%)
Firms with outliers in changes in the	27,057,805	921,597	689,226
number of establishments	(44.84%)	(16.32%)	(14.28%)
Firms with 99+ establishments	25,397,415	871,673	688,958
	(42.09%)	**(15.44%)**	**(14.27%)**

This table presents the number of observations left after each step of our data selection process. The parentheses below each number show the share of this total of the total labor force in the private sector.

From this regression, we the estimated year fixed effects as the predicted average value of $\hat{\bar{C}}_t^o = \hat{\delta}_{dec,t}^o$ for each occupation o in year t.

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

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

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

$$\hat{\bar{C}}_t^o = \frac{\hat{L_{ot}}}{L_t} \cdot \hat{\bar{D}}_t^o.$$

Now, consider the change in $\hat{\bar{C}}^o$ between 1991 and 2016:

$$\Delta_{25}\hat{\bar{C}}^o \equiv \hat{\bar{C}}^o_{2016} - \hat{\bar{C}}^o_{1991} = \frac{\hat{L_{o,2016}}}{L_{2016}} \cdot \hat{\bar{D}}^o_{2016} - \frac{\hat{L_{o,1991}}}{L_{1991}} \cdot \hat{\bar{D}}^o_{1991}. \tag{A2}$$

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

$$\Delta_{25}\hat{\bar{C}}^o = \Delta_{25}\left(\frac{\hat{L_o}}{L}\right) \cdot \hat{\bar{D}}^o_{2016} + \Delta_{25}\hat{\bar{D}}^o \cdot \frac{\hat{L_{o,1991}}}{L_{1991}}. \tag{A3}$$

We use equation (A3) to decompose the contribution of each of the occupational category 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 $\frac{\hat{L_{o,2016}}}{L_{2016}} \cdot \hat{\bar{D}}^o_{1991}$ to the right-hand side of equation (A2). 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 can 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:

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

where we denote with the subindices c and l those establishments that are relatively close and relatively far from the HQ, respectively. The results from this decomposition are shown in Table A3.