Economics Working Papers

2015-26

Trade Shocks, Firm Hierarchies and Wage Inequality

Benjamin Friedrich

DEPARTMENT OF ECONOMICS AND BUSINESS ECONOMICS
AARHUS UNIVERSITY

Trade Shocks, Firm Hierarchies and Wage Inequality

Benjamin Friedrich*

First Version: December 15, 2013
This Version: November 13, 2015

Abstract

This study uses administrative employer-employee data and firm-level trade data from Denmark to provide evidence for a novel mechanism through which trade affects wage inequality: changes in firm hierarchies. This mechanism is motivated by the empirical fact that within-firm wage variation across the hierarchical levels of top manager, middle manager, supervisor and worker accounts for an important component of wage inequality. It is comparable in magnitude to wage differences across firms. To identify the causal effect of trade shocks on firm hierarchies and wage inequality, I use two distinct research designs for firm-level trade shocks—one based on foreign demand and transportation costs, and the other using the Muslim boycott of Danish exports after the Cartoon crisis. Both identification strategies suggest robust effects of trade shocks on within-firm inequality through changes in hierarchies. Consistent with models of knowledge-based or incentive-based hierarchies, firm-level trade shocks influence organizational choices through production scale. Adding a hierarchy layer significantly increases inequality within firms, ranging from 2% for the 50-10 wage gap to 4.7% for the 90-50 wage gap.
JEL Codes: F14, F16, J31, L22, L23

*Yale University, 28 Hillhouse Avenue, New Haven, CT 06511, Tel.: 1-203-809-7254, e-mail: benjamin.friedrich@yale.edu.
Acknowledgment: I am grateful to Joseph Altonji, Lorenzo Caliendo, Penny Goldberg and Costas Meghir for their invaluable advice. I received helpful comments from Andy Bernard, Henning Bunzel, Gene Grossman, Elhanan Helpman, Magne Mogstad, Peter Schott, Valerie Smeets, Frederic Warzynski, Andrea Weber and Rune Vejlin as well as from seminar participants at Yale University, Aarhus University, the MAYBE Workshop 2014 at the University of Mannheim, the IAB/ZEW Conference on Globalization and the Labor Market 2015, and the Danish International Economics Workshop 2015. I thank the Labor Market Dynamics Group (LMDG), Department of Economics and Business, Aarhus University and in particular Henning Bunzel for support and making the data available. LMDG is a Dale T. Mortensen Visiting Niels Bohr professorship project sponsored by the Danish National Research Foundation. My research has been supported financially by the Yale Economics Department. All errors are my own.

1 Introduction

How does globalization affect wage inequality? This question has been of main interest to trade economists and labor economists for several decades.[1] Recently, trade scholars have proposed a variety of new channels, such as offshoring, technology and skill upgrading, or labor market frictions, through which international trade affects wages across heterogeneous firms.[2] Labor scholars have also emphasized the significant share of overall wage inequality that is explained by wage variation across firms.[3] Yet much less is known about wage inequality *within* firms and how it is affected by international trade.

Motivated by the recent theoretical literature on trade and firm organization (Antràs, Garicano, and Rossi-Hansberg 2006; Caliendo and Rossi-Hansberg 2012; Chen 2013) and the empirical study of firm hierarchies by Caliendo, Monte, and Rossi-Hansberg (2015), this paper focuses on firm hierarchies as an important characteristic of firms that may affect the wage structure within firms. This focus is also motivated by studies that document the importance of occupations and job tasks of workers to explain wage inequality (Autor, Levy, and Murnane 2003; Autor, Katz, and Kearney 2008), yet without considering the role of firm affiliation. The main goal of this paper is to measure the causal effect of trade on within-firm wage inequality through changes in firm hierarchies.

Firm hierarchies - defined as the number of managerial and supervisory levels within firms - provide a novel mechanism through which trade affects wage dispersion across workers. Models of knowledge-based or incentive-based hierarchies suggest that the optimal number of hierarchy layers increases with production scale. These models interpret managers as fixed costs that lower marginal costs by making workers more productive; additional managers will decrease average costs if production scale is sufficiently large. Adding hierarchical layers has implications for the wage distribution within firms because higher-level managers receive high wages due to their productive effect on a large range of workers. At the same time, wages decrease for workers at the production level because managers can be considered either problem solvers whose knowledge reduces skill requirements of workers or supervisors whose monitoring substitutes for wage incentives to prevent shirking.[4]

Since trade affects production scale, firms may respond to trade shocks by changing their

[1] Feenstra and Hanson (2003) and Goldberg and Pavcnik (2007) review the empirical literature based on classical trade models before the focus shifted to heterogeneous firms within industries.

[2] See Grossman and Rossi-Hansberg (2008) and Hummels et al. (2014) on offshoring, Bernard and Jensen (1997) and Bustos (2011) on technology upgrading, Verhoogen (2008) on skill upgrading and Davidson, Matusz, and Shevchenko (2008) and Helpman, Itskhoki, and Redding (2010) on frictions. Harrison, McLaren, and McMillan (2011) provide an overview of the recent literature on trade and inequality.

[3] See Abowd, Kramarz, and Margolis (1999) and recent studies by Card, Heining, and Kline (2013), Helpman et al. (2012) and Akerman et al. (2013) for analyses of wage variation across firms.

[4] See Garicano (2000); Garicano and Rossi-Hansberg (2006); Caliendo and Rossi-Hansberg (2012) for theoretical contributions on knowledge-based hierarchies and Williamson (1967); Calvo and Wellisz (1978); Calvo and Wellisz (1979); Qian (1994); Chen (2013) on incentive-based hierarchies.

hierarchical structure and thereby adjusting their internal wage structure. Knowledge-based hierarchy theories assume that wage differences across layers are determined by knowledge differences, whereas incentive-based hierarchies imply higher wages for observationally equivalent workers in higher layers because managers receive less monitoring and their effort is more valuable. As a result, the theory suggests higher wage inequality within firms with more hierarchical layers. Yet, different models emphasize distinct sources of inequality. As firms restructure, knowledge-based hierarchy models predict wage changes based on changes in worker skills, while incentive-based models predict changes in residual wages based on the new rank structure.

This paper uses matched employer-employee data from Denmark over 1999-2008 to first show that wage variation across hierarchical layers *within* firms constitutes a systematic component of overall wage inequality - comparable in importance to wage differences across firms. Following Caliendo, Monte, and Rossi-Hansberg (2015), I measure firm hierarchies based on workers' occupations, focusing on vertical relationships between top managers, middle managers, supervisors and workers. These relationships can represent monitoring, supervision and support from superiors in a vertical communication structure as argued in the theoretical literature. For the sample of exporters, I document that wage variation across hierarchy layers within firms accounts for 22.5% of overall wage inequality, while variation across firms accounts for 27.1%. This role of hierarchies within firms is robust to accounting for observable and unobservable differences across workers in different layers. This wage variance decomposition motivates the subsequent focus on the hierarchical structure of firms.

I document several new stylized facts about the relationship between hierarchies and wage inequality within firms. First, firms with more hierarchy layers have on average higher wage inequality among their workers, both in terms of overall wage dispersion and in terms of the wage gap between the top and the bottom of the firm. Second, organizational restructuring is positively related to changes in wage inequality. As firms add hierarchy layers, overall wage dispersion as well as the 90-10 wage gap and the interquartile range inside the firm increase significantly. Third, these changes in within-firm inequality are not driven purely by compositional changes in the workforce. I also find significant changes in residual inequality after controlling for observable worker characteristics. Moreover, wage inequality among stayers at a restructuring firm changes as well, even though the effect is much stronger when dropping layers compared to adding layers. Overall, these facts are consistent with theoretical predictions from hierarchy models. The empirical analysis examines whether this relationship is causal and to what extent it can be triggered by trade shocks.

I estimate the effect of trade on wage inequality through firm hierarchies using two different identification strategies - one based on foreign demand and transportation costs, and the other using the Muslim boycott of Danish exports after the Cartoon crisis. The first strategy uses firm-level export data by product-destination to construct firm-specific trade shocks.

These shocks measure changes in import demand from destination countries for a particular firm's products and changes in transportation costs for different product-destination pairs over time. For each firm, I construct annual demand shocks and transport cost shocks following Bartik (1991) and Hummels et al. (2014) by weighting foreign demand and transport costs by the importance of different product-destinations in a firm's export activities in a presample period.[5] The Bartik trade shocks allow me to estimate the effect of trade on hierarchies and wage inequality across a large number of firms, and the long panel structure of the data is crucial to account for unobserved firm characteristics that influence organizational choice and wage inequality.

The results show that higher import demand and lower transport costs lead to higher sales and organizational restructuring. Even small changes in the trade environment can trigger changes in firm hierarchies because the number of hierarchical layers is discrete and a small increase in production scale can imply crossing the threshold for readjustment. More importantly, adding a hierarchy layer significantly increases inequality within firms, ranging from an increase of 2% for the wage gap between the 50th and 10th percentile of workers to the largest increase of 4.7% for the 90-50 wage gap. These disproportionate effects for managers are consistent with strong wage increases as managers are able to better leverage their extraordinary knowledge and skills. These findings are robust to multi-product and multi-plant firms. Firms that do not engage in offshoring respond slightly less to changes in production scale, suggesting that FDI and domestic firm organization are complements rather than substitutes. Domestic firms show a smaller response to revenue shocks, which is consistent with a scale effect of exporting.

I take advantage of detailed worker-level data to estimate changes in within-firm wage inequality for both log wages and residual wages to test the different implications of knowledge-based and incentive-based hierarchy theories. In particular, residual wages exclude observable measures of knowledge in the data such as experience, tenure, education and occupation but also unobservable worker quality. The analysis shows that the majority of the change in wage structure is due to adjustments in worker knowledge. Yet, there is also a role for wage differences that are orthogonal to worker characteristics and can therefore be purely attributed to ranks within the firm. These findings are consistent with predictions from theories of knowledge-based and incentive-based hierarchies and are an important contribution to studying trade and within-firm wage structures.

The second identification strategy uses the "Cartoon Crisis" in 2006 as a natural experiment that illustrates the effect of a particular trade shock on sales, firm hierarchies and wage structure. On September 30, 2005, Denmark's largest newspaper *Jyllands-Posten* published 12 caricatures of the prophet Muhammad, which set in motion large protests and a boycott of

[5]Similar IV strategies have been used recently at the local labor market level by Autor, Dorn, and Hanson (2013).

Danish products across the Muslim world starting in January 2006. In 2006, this boycott led to a decrease in Danish exports to Muslim countries by more than 200 million dollars, which corresponds to a drop by 17% in exports to these destinations compared to 2005. Firms that had been exporting to Muslim countries prior to 2006 experienced a differential drop in total sales by 4.2% on average. I find that this unique trade shock led to a significant reduction in hierarchical layers; the incidence of delayering in the treatment group increases by 17%. Moreover, I estimate a 2% decrease in the 90-50 wage gap for firms with median exposure in terms of total exports to Muslim countries before the crisis, compared to firms without previous ties to Muslim countries. Firms affected by the boycott respond by systematic layoffs and demotions, in particular at the management level. This response leads to a decrease in hierarchy layers and a reduction in wage dispersion within these firms. Individual-level demotions and large negative effects on individual wages suggest an overall decrease in inequality.

This paper is closely related to Caliendo, Monte, and Rossi-Hansberg (2015) who first introduced a mapping from worker occupations to hierarchical layers within firms. These authors show that occupational layers within French firms are hierarchical in terms of wages and number of workers and that restructuring goes along with changes in average wages and workforce size of individual layers.[6] My paper is the first to estimate the causal mechanism how firms choose their hierarchical structure in response to exogenous trade shocks and how restructuring affects the internal wage structure.

I use a large panel data set of firms to conduct a broad analysis of patterns of inequality and firm organization for an important share of the economy. Thus this paper complements studies focusing on detailed hierarchies for a small subset of firms (Rajan and Wulf 2006) or one particular firm (Smeets, Waldman, and Warzynski 2013). Denmark provides an interesting setting to study the relationship between trade, hierarchical structure and wage structure because trade accounts for a large share of firms' activities and labor market institutions are sufficiently flexible to allow for adjustments in both employment and wages.[7] Moreover, Denmark has low levels of wage inequality compared to other OECD countries and might provide a lower bound in terms of the causal effects on wage inequality that I find for a given change in the number of hierarchy layers.[8]

My empirical analysis complements the theoretical literature on knowledge-based and incentive-based hierarchies with heterogeneous firms (Caliendo and Rossi-Hansberg 2012; Chen 2013). Specifically, I use exogenous variation from firm-level trade shocks to directly test the theoretical prediction of a positive relationship between production scale and hier-

[6]See also Tag (2013) for results on the hierarchical structure of Swedish firms.

[7]Danish labor market institutions provide low barriers to hiring and firing (Andersen and Svarer 2006) and wage bargaining in the private sector has been largely decentralized to the firm and individual match level (Dahl, Le Maire, and Munch 2013).

[8]See Koske, Fournier, and Wanner (2012) for a comparison of labor income inequality across OECD countries.

archical structure. Moreover, detailed worker-level data allow me to distinguish the effects of restructuring on log wage and residual wage inequality to test the explanatory power of different hierarchy theories for changes in the wage structure. The findings in this paper also relate to a recent literature on firm growth that finds increases in the 90-50 wage gap within firms that expand, see Mueller, Ouimet, and Simintzi (2015). I provide a mechanism for this empirical pattern by showing that these average changes in within-firm inequality are driven by firms that decide to restructure.

The rest of the paper is structured as follows. Section 2 introduces the main dataset and institutional background, while Section 3 motivates the analysis providing stylized facts on firm organization and wage inequality in Denmark and emphasizes the importance of firm hierarchies in wage variance decompositions. Section 4 describes the empirical strategy based on firm-level trade shocks and provides estimation results for dynamic organizational choice and the relationship between firm hierarchies and within-firm wage inequality. Section 5 studies the Cartoon Crisis of 2006 as a natural experiment for the effect of trade shocks on organizational choice. Section 6 provides further robustness checks and Section 7 concludes.

2 Data and Institutional Background

2.1 Data

The data for this analysis are drawn from Statistics Denmark, which collects labor market data much more comprehensively than most other statistical offices. I use the Danish matched employer-employee data for the universe of firms from the Integrated Databases for Labour Market Research (IDA) to construct measures of firm organization for each firm-year based on occupational information of primary employees in November. IDA contains the Danish occupational code DISCO, which is a modified version of the ILO international standard classification of occupations. I create a mapping from these occupations onto four different hierarchical levels following Caliendo, Monte, and Rossi-Hansberg (2015) and as described in detail in Appendix A.1. This procedure provides a measure of the total number of hierarchy layers in the firm that can be used in the subsequent analysis, $L \in \{1, 2, 3, 4\}$.[9] In addition to occupational information, the matched data contains information on hourly wages and total salary per worker that I aggregate into measures of wage inequality at the firm level. This information is combined with firm-level outcomes from the Danish Business Register (GF) such as sales, value added and sectoral information using firm identifiers from the Firm-Integrated Database for Labor Market Research (FIDA).[10]

[9] For some firm-years, occupations are unspecified for a large group of workers. I drop firms where workers with unknown occupations account for more than 20% of total hours worked.

[10] I lose a small fraction of firms from this merge to the extent that small firms with less than 50 workers do not report accounting data every year.

Finally I merge this dataset with the Danish Foreign Trade Statistics Register which uses the same firm identifier as FIDA. The trade register provides firm-level trade values and weights by product-destination pairs at CN-8-digit product level. In order to make the Danish trade data compatible with bilateral trade flows reported by UN Comtrade, I aggregate this information at the 6-digit HS level by firm-destination-year. This firm-level information is combined with data on bilateral trade flows by 6-digit product from UN Comtrade.[11] Moreover, I use U.S. Imports of Merchandise data 1999-2006, distance data from the Penn World Tables and data on annual oil prices (Brent) from the U.S. Department of Energy to estimate predicted transport costs at the product-destination level following Hummels (2007). I describe the details of this procedure in Appendix A.3. I then merge these transport costs with the firm-level trade data.

I define the baseline sample as the universe of private sector exporting firms in Denmark for the sample period 1999-2008 because the identification strategy crucially depends on trade data. The most recent years available, 2009 and 2010, are excluded because there is a major revision of the occupational code in 2009. The analysis focuses on exporting firms because export shocks can be directly interpreted as a shock to overall production scale. In contrast, import shocks are ambiguous because they can either replace or complement domestic production and organization. In order to control for endogenous entry, I restrict the sample for my estimation to preexisting exporters. Yet this is not a major concern because new exporters are typically small compared to established exporters.[12] The final sample captures about 82% of sales of all exporting firms in the economy and it accounts for 38.4% of employment and 54.5% of total revenue in the Danish private sector over 1999-2008.

2.2 Labor Market, Trade and Inequality in Denmark

Denmark can be considered a prototype small open economy. Danish exporters in my sample account for more than half of all revenue in the private sector; these firms sell a large share of their production abroad because the domestic market is quite small.[13] As a result, changes in the trade environment will have large effects for Danish firms. About two-thirds of Denmark's trade flows occur within the European Union. The main export partners over the observation period are Germany, Sweden, UK, Norway and U.S. with relatively stable shares across time

[11] One difficulty in this procedure is the fact that some exports reported by Danish firms are not reported in the bilateral trade data from Comtrade. As a result, I compute average import demand over all 6-digit product groups that belong to the same 4-digit group as the missing 6-digit category in order to avoid selection issues.

[12] Exporters remain in the sample from the first until the last year I observe them exporting in the data. This includes gap years of zero export value. I choose this definition to capture the entire period during which a firm's export activities are still ongoing.

[13] Denmark is ranked among the most open countries in the world. For the last year of my sample, 2008, Denmark's openness index, the ratio of imports and exports of goods relative to GDP, as computed by the OECD was above 50%, compared to 40% for another Scandinavian country Norway, 30% in Italy and 15% in the U.S., see http://stats.oecd.org for details.

except for the decline in Germany's share. China's impact is small but slightly increasing over time. The trade environment for many firms in terms of exchange rate fluctuations is stable because the Danish currency (Danish kroner, DKK) is pegged to the Euro and floats within a very narrow band since Denmark joined the European exchange rate mechanism ERM-II.[14]

The Danish labor market is characterized by the flexicurity system, with flexible hiring and firing but a strong social security system during unemployment (Andersen and Svarer 2006). Wage bargaining in the private sector has been largely decentralized to the firm-level or individual worker level (Dahl, Le Maire, and Munch 2013). As most developed countries, Denmark has experienced an increase in income inequality over the last twenty years. This overall trend is similar to but less pronounced than the experience of other countries, notably the U.S., see Lemieux (2008) and a recent comparison of OECD countries by Koske, Fournier, and Wanner (2012) for example. Denmark is an interesting benchmark case for my study because labor market institutions are sufficiently flexible to allow for adjustments in both employment and wages, and the effects in other countries with higher wage inequality could potentially be stronger.

3 Stylized Facts

3.1 Stylized Facts: Firm Organization

Table 1 shows that there is considerable variation in organizational outcomes across firms. Note that the level of observation is a firm-year, so as a firm changes its hierarchy over time, it will appear in different firm groups in the table. For exporters in the main sample, the most common choice is three or four hierarchical layers. The group with one layer has the smallest number of observations.

Table 1 confirms the well-known fact that exporters are on average larger in terms of employment and sales and pay higher wages (see Bernard and Jensen (1999) for the US and Eriksson, Smeets, and Warzynski (2009) for Denmark). In particular, these patterns also hold within each group of firms with the same number of hierarchy layers. Furthermore, average wages are higher for firms with a higher number of hierarchy layers for both exporters and all private firms. This is in line with the results for French firms reported in Caliendo, Monte, and Rossi-Hansberg (2015) and for Swedish firms in Tag (2013). Firm size in terms of hours is also positively correlated with firm organization.

The key descriptive statistic with respect to the subsequent econometric analysis is the relationship between firm organization and sales. Incentive-based and knowledge-based hierarchy models make strong predictions about the positive relationship between firm size and

[14] For more detailed stylized facts about Danish exporters in the last decade, see Abreha, Smeets, and Warzynski (2013).

Table 1: Descriptive Statistics on Wages and Hours by Firm Hierarchy

	Firm-Years		Hourly Wages		Total Hours		Sales		Exports	
Hierarchy	All Firms	Sample	All	Sample	All	Sample	All	Sample	All	Sample
1	453,481	11,474	154.2	176.4	3.6	5.7	3.3	12.2	3.0	3.1
2	176,618	17,624	168.4	182.4	11.9	18.4	11.4	28.5	6.0	7.2
3	104,074	25,279	187.4	191	48.4	77.8	52.5	113.1	27.4	31.5
4	43,670	20,390	200.1	195.4	189.5	223.7	219.1	319.3	85.4	90.9
Total	777,843	74,767	164.4	187.9	21.9	92.5	24.3	133.9	33.7	38.8

Notes: Firm hierarchy is measured as the number of hierarchy layers. Real average hourly wages are reported in DKK (base year 2000, 1 USD = 8.083 DKK), hours in thousands, sales and exports in millions of DKK. All refers to the full set of private sector firms in Denmark, while Sample stands for the set of exporting firms used in the main analysis.

hierarchies.[15] Yet, firm-level idiosyncrasies in reality makes a direct comparison with this theoretical result difficult. In order to illustrate the size distribution of firms with different numbers of hierarchy layers, Figure 1 shows a kernel density plot of sales for each group of firms. The data show a clear pattern of higher sales for firms with a higher number of layers. The goal of the subsequent analysis will be to trace out the causal effect of production scale on firm organization to test the model mechanism against the alternative that other factors lead to spurious correlation between firm size and organization.

Figure 1: Sales Distribution by Firm Organization Types

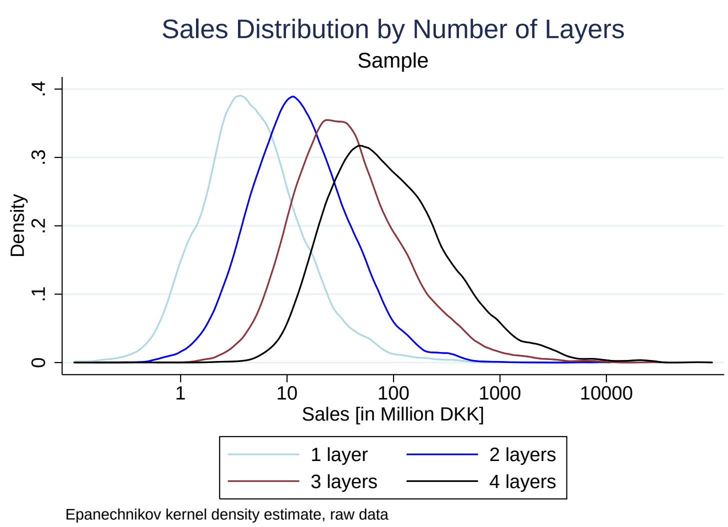


Table 2 documents stylized facts on restructuring. Panel A reports per-period transition probabilities for firms between different numbers of hierarchy layers. Overall, the results

[15]Intuitively, these models consider additional management layers "fixed costs" that decrease marginal costs because of better monitoring or problem solving capacities. Hence, expansion makes adding layers attractive to lower overall average costs and to increase productivity. See for example Proposition 4 in Caliendo and Rossi-Hansberg (2012) and Proposition 1 in Chen (2013).

show that there is considerable mobility in terms of hierarchical structure for a given firm over time. Looking at the main diagonal, firms with one or four hierarchy layers are the most stable groups. In contrast, firms with two or three layers restructure quite frequently, but still more than 70% of these firms remain unchanged from one year to the next. For exporting firms with two or three layers, upwards mobility is more likely than downwards mobility over the sample period. Firm exit rates are higher for firms with fewer layers but exit here is defined as exit from the sample, which includes cases with missing data in subsequent years or the fact that the firm stops exporting.

Firms add and drop layers in a systematic way as illustrated in Panel B of Table 2. The majority of firms with at least two hierarchy layers in the previous period add either middle managers or top managers as they increase their number of layers. In contrast, firms with only one hierarchy layer mostly add a supervisory level. This finding holds in reverse for firms that reduce their number of hierarchy levels. Firms with previously two layers lay off their supervisory layer, whereas firms with three or four layers dispose of their middle or top management level in a large majority of cases.

Panel C shows that there are also systematic patterns how firms add and drop these layers respectively. The higher the occupational layer that is added to the firm hierarchy, the higher the probability of promoting managers internally. Only about 57% (40%) of workers in new middle (top) management layers are hired externally. For dropping layers, the pattern is U-shaped. If a firm drops the worker layer or the top management level, these workers mostly leave the firm, whereas workers in dropped intermediate layers are more likely to transition to other jobs within the same firm.

Finally, Panel D shows individual-level wage changes for workers at firms that restructure. In particular, entrants into firms that add layers achieve large wage gains relative to their previous job, whereas leavers of firms that drop layers experience low wage growth. Gains are largest for workers that are promoted, whereas real wages for demoted leavers decrease. I will analyze the causal effect of trade shocks on restructuring and individual wage changes in more detail in the context of the Cartoon Crisis below.

3.2 Wage Variance Decomposition: The Role of Hierarchies

The previous literature in trade and labor has found that wage differences across firms explain a large share of overall wage inequality and account for a large share of changes in inequality, see Helpman et al. (2012) and Card, Heining, and Kline (2013). Yet as the following discussion will show, there is also a systematic component of wage variation across hierarchy layers within firms. In particular, I illustrate the importance of this component by decomposing wage variation into three components: (i) wage variance across firms, (ii) across hierarchy layers within firms and (iii) within layers within firms.

Table 2: Stylized Facts on Restructuring

Panel A: Transition probabilities by number of hierarchy layers

	from\to	1	2	3	4	exit
#Layers	1	0.776	0.139	0.019	0.004	0.062
	2	0.066	0.707	0.173	0.02	0.034
	3	0.004	0.088	0.758	0.136	0.013
	4	0.001	0.009	0.145	0.84	0.004

Panel B: Conditional Probabilities of adding or dropping occupational layers

		Conditional on adding layers			
Share of firms that add ...		workers	supervisors	middle managers	top managers
	1	0.234	0.486	0.223	0.057
#Previous Layers	2	0.096	0.287	0.474	0.143
	3	0.026	0.108	0.305	0.561
		Conditional on dropping layers			
Share of firms that drop ...		workers	supervisors	middle managers	top managers
	2	0.200	0.505	0.239	0.055
#Previous Layers	3	0.067	0.244	0.509	0.180
	4	0.014	0.099	0.315	0.573

Panel C: Hiring and firing compared to promotions and demotions

Conditional on adding/dropping...	workers	supervisors	middle managers	top managers
Share of new hires in added layer	0.815	0.666	0.568	0.396
Share of firing in dropped layer	0.800	0.407	0.453	0.636

Panel D: Wage growth for hiring and firing compared to promotions and demotions

Firms that add layers	Stayers			Entrants		
	same layer	promotion	demotion	same layer	promotion	demotion
Worker Obs	294,521	19,224	7,057	62,679	7,773	5,593
Wage growth	0.023	0.039	0.018	0.064	0.095	0.029

Firms that drop layers	Stayers			Leavers		
	same layer	promotion	demotion	same layer	promotion	demotion
Worker Obs	268,228	8,069	12,031	65,047	7,320	6,833
Wage growth	0.026	0.047	0.007	0.001	0.062	-0.031

Note: All results are for the main sample of Danish exporters 1999-2008. Individual wages for the wage growth analysis are deflated by CPI using base year 2000.

Table 3: Wage Variance Decomposition

		Share of total wage variance explained by wage variation...		
Panel A: Log Wages	sd(wages)	across firms	within firms, across layers	within firm-layers
All Firms	0.208	34.5	18.9	46.6
Sample	0.173	27.2	22.5	50.3
Panel B: Residual Wages	sd(wages)	across firms	within firms, across layers	within firm-layers
All Firms (worker controls)	0.112	25.7	12.3	62.0
Sample (worker controls)	0.096	16.2	13.4	70.4
All Firms,Worker-FE	0.037	16.9	7.3	75.9
Sample, Worker-FE	0.029	8.0	5.7	86.3
Panel C: Log Wages	sd(wages)	across firms	within firms, across occ	within firm-occupation
All Firms	0.208	34.6	30.8	34.6
Sample	0.173	27.2	34.4	38.4

Note: All wage decompositions are weighted by hours worked of each employee and exclude outliers with hourly wages below the 0.25-percentile and above the 99.75-percentile of the hourly wage distribution by year. The first two rows in Panel B use wage residuals based on column (3), the last two rows use residuals from column (5) in Table A.II.

Pooling wage data for all exporters in the sample over 1999-2008, Table 3 shows that 27.1% of total wage variation is captured by variation across firms and the remaining 72.9% are accounted for by wage dispersion within firms. This overall decomposition is comparable to other findings in the literature. For example, Akerman et al. (2013) report a contribution of 21% of variation from between-firm differences in wages for Sweden in a similar time period as my sample for Denmark. Yet their study does not provide separate results only for exporting firms nor do they consider hierarchical structures within firms. My results show that this new dimension of wage variation across hierarchy layers within firms accounts for 22.5% of total wage variation. This is a strong motivation for the focus of this paper on firms' organizational choices and within-firm wage structure.

Knowledge-based hierarchy theories assume that wage differences across layers are entirely driven by differences in worker knowledge, whereas incentive-based approaches argue that there should be wage differences across layers even after controlling for worker characteristics. To account for observable and unobservable differences of workers across hierarchical layers, I run Mincer wage regressions of log wages on worker observables and worker fixed-effects before decomposing residual wage inequality.[16] Using wage residuals that control for age, education, experience and tenure of workers, Panel (B) of Table 3 illustrates that the share of residual wage variance explained by wage differences across layers within firms (13.4%) is almost as large as the share explained by differences across firms (16.2%). Overall the share of variation explained across firms or across layers within firms decreases when looking at residual wage

[16] Appendix Table A.II reports the estimation results for this exercise.

variance. But the standard deviation of residual wages is also 40-50% smaller than for log wages without controlling for worker observables.[17] Finally, taking worker unobservables into account, the variation of residual wages as well as the explanatory power of firms and firm-layers further decrease, but the role for variation across layers within firms remains comparable to wage variation across firms.

Decomposing wage variation across 3-digit occupations instead of hierarchy layers in Panel C of Table 3 shows that layers that group many different occupations capture two-thirds of wage variation across different occupations within firms. Hence, hierarchy layers describe important aspects of wage inequality within firms. In sum, a large share of these wage differences across layers is driven by worker characteristics such as education or experience but there are still systematic wage differences across these layers even after controlling for observable worker characteristics and unobservable worker quality.

3.3 Stylized Facts: Hierarchies, Restructuring and Within-Firm Inequality

I illustrate the pattern between wage inequality and hierarchies within firms in the data using firm-level regressions

$$\log\left(\text{inequality}_{jt}\right) = X_{jt}\beta + u_j + u_t + u_s + \epsilon_{jt}.$$

I include time and industry fixed effects u_t and u_s to control for aggregate shocks across all firms or within a given industry, and I conduct the analysis with firm-fixed effects u_j to account for idiosyncratic differences across firms. X_{jt} are firm characteristics that might play a role for inequality, in particular the number of layers. [18] Table 4 reports a strong positive relationship between the number of layers and inequality measures such as the standard deviation of wages and the 90-10 wage gap within firms.[19] If a firm increases hierarchy layers over the sample period, this on average goes along with an increase in the 90-10 wage gap by 6.7%. The point estimates for layers in specifications using residual wages are still highly significant and only decrease slightly in magnitude compared to the log wage specification. This result highlights that hierarchy layers represent more than groups of workers who differ by observable and unobservable characteristics. Instead, different hierarchy structures imply significantly different wage schedules, even for observationally equivalent workers.

Next, I formally illustrate the empirical patterns between restructuring and within-firm

[17] The decrease in the share of variation explained can be interpreted as evidence in favor of assortative matching of workers along observable dimensions across firms or across layers within firms. It is a comforting result because as workers become more comparable to each other by taking out variation due to observable differences, wages move closer to the law of one price in a competitive labor market.

[18] Note that adjusting the hierarchical structure goes along with changes in employment; hence, controlling for the size of the workforce would not be theoretically justified.

[19] I report more detailed stylized facts in the online appendix, http://goo.gl/AXKEce.

Table 4: Firm Organization and Within-Firm Wage Inequality

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	log(standard deviation of wages)			log(90-10 wage gap)		
	log wages	residuals	residuals	log wages	residuals	residuals
		worker controls	worker FE		worker controls	worker FE
layers	0.0548***	0.0454***	0.0569***	0.0670***	0.0590***	0.0632***
	(0.006)	(0.006)	(0.013)	(0.009)	(0.009)	(0.016)
Obs	68,090	68,090	68,090	68,090	68,090	68,090
Firms	12,470	12,470	12,470	12,470	12,470	12,470
Adj.R^2	0.500	0.445	0.386	0.538	0.483	0.434

Notes: All regressions include industry, time and firm fixed effects. Residual wages in column (2) and (5) are based on column 3 of Table A.II, while column (3) and (6) use residuals from column 4 in Table A.II. Robust standard errors using firm clusters in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

inequality by running within-firm regressions of the form

$$\Delta\text{inequality}_{jt} = \beta_1 1\left(\text{add}_{jt}\right) + \beta_2 1\left(\text{drop}_{jt}\right) + u_j + u_t + u_s + \epsilon_{jt}$$

where the main regressors of interest are dummies for adding or dropping layers. The results in Table 5 show that wage inequality on average increases for firms that add layers and vice versa for firms that choose to delayer. An exporting firm that increases the number of hierarchy layers on average increases log wage dispersion by 5.3%, the 90-10 wage gap increases by 6.3% and the interquartile range increases by 5.0%. Consistent with adding supervisors and middle managers, the 50-10 wage gap increases more in percentage terms than the gap between the 90th and 50th percentile. The results for dropping layers turn out to be the exact mirror image of these findings and the magnitudes are very similar.[20]

Note that the relationship between organization and within-firm inequality is by no means mechanical. Firm organization is measured based on occupations, not wages. Hence a change in organizational structure does not automatically imply a change in wage variation in a certain direction. As shown in Table 2 above, an increase in hierarchy layers often implies introducing middle management as a firm expands in the data. As a consequence, these managers could potentially narrow the gap between top management and workers in terms of wage differences. Alternatively, the firm might add a management layer but at the same time hire many more production workers as well. As a result, the change in the workforce composition is crucial to understand the direction of the change in inequality.

The key question to distinguish different theories of hierarchies is whether there is an

[20] The paper focuses on the sample of exporting firms, but the pattern for all private firms is very similar and is available upon request.

Table 5: Restructuring and Within-Firm Inequality

	(1)	(2)	(3)	(4)	(5)
log wages	Δlog(sd wages)	Δlog(90-10 gap)	Δlog(75-25 gap)	Δlog(90-50 gap)	Δlog(50-10 gap)
add	0.0528***	0.0634***	0.0498***	0.0585***	0.0789***
	(0.012)	(0.017)	(0.010)	(0.018)	(0.019)
drop	-0.0565***	-0.0780***	-0.0341**	-0.0769***	-0.0836***
	(0.013)	(0.016)	(0.013)	(0.015)	(0.020)
Obs	59,369	59,369	59,369	59,369	59,369
Firms	11,866	11,866	11,866	11,866	11,866
R^2	0.188	0.185	0.178	0.192	0.147

Notes: All regressions are based on residual wages from specification (3) in Table A.II and include industry-time and firm fixed effects. Robust standard errors using firm clusters in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

independent role for hierarchical structure in determining wage inequality or whether the positive correlation between restructuring and within-firm inequality is driven by changes in workforce composition and worker characteristics. Comparing column (1) to (3) and column (5) to (7) in Table 6 shows that the change in inequality is not only driven by changes in observable characteristics of the workforce. The magnitude of the coefficients on adding and dropping layers is only slightly lower for changes in residual wage inequality. Moreover, columns (4) and (8) show that changes in the number of layers are associated with larger changes in residual wage inequality when taking worker unobservables into account by using worker fixed effects in the Mincer wage regression. These results suggest that there is a change in the structure of wages within firms as the hierarchy changes, even for observationally equivalent employees.

Finally, I identify the stable workforce as the set of workers who stay at a firm for two subsequent years and I measure changes in wage inequality only for this subset of workers. Changes in the hierarchy potentially affect this group of workers because they receive training, promotions and demotions to reorganize the firm and their productivity is affected by new hires and changed responsibilities as well. Yet, the results in columns (2) and (6) of Table 6 suggest that changes in inequality among stayers are not the dominant driver of the overall change in within-firm inequality, in particular for firms that reduce the number of layers. Instead, the wage structure changes mostly through hiring and firing during the restructuring process. For example, as a firm adds a hierarchy layer, new employees receive wages different from the wage schedule of the existing workforce, even conditional on observable and unobservable worker characteristics. As a result, I observe only a small change in inequality among stayers but a large increase in inequality overall. Similarly, as a firm reduces the number of layers, wages among stayers are relatively unaffected, but the overall wage schedule of the firm changes dramatically if firms selectively lay off workers with particularly high or low salaries while incentivizing their most promising employees to stay with the firm. This adjustment

Table 6: Restructuring, Worker Characteristics and Within-Firm Inequality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Δlog(sd wages)				Δlog(90-10 gap)			
	Log Wages	Stayers	Controls	Worker FE	Log Wages	Stayers	Controls	Worker FE
add	0.0528***	0.0111	0.0508***	0.0806***	0.0634***	0.0100**	0.0577***	0.0763***
	(0.012)	(0.007)	(0.013)	(0.011)	(0.017)	(0.004)	(0.015)	(0.017)
drop	-0.0565***	0.0073	-0.0503***	-0.0720**	-0.0780***	0.0087	-0.0669***	-0.0836**
	(0.013)	(0.006)	(0.011)	(0.029)	(0.016)	(0.005)	(0.014)	(0.034)
Obs	59,369	37,610	59,369	59,369	59,369	58,842	59,369	59,369
Firms	11866	10456	11866	11866	11866	11723	11866	11866
R^2	0.188	0.324	0.202	0.151	0.185	0.264	0.207	0.162

Note: All regressions include industry, time and firm fixed effects. Columns (1)-(4) report results for the standard deviation of wages, columns (5)-(8) focus on the 90-10 wage gap. Specifications (3) and (7) use wage residuals controlling for worker observables as in column 3 of Table A.II, specifications (4) and (8) add worker fixed effects as in column 5 of TableA.II. Robust standard errors using firm clusters in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

along the extensive margin of employees is consistent with the adjustment process described in Table 2 and is facilitated by low employment protection in the Danish labor market. In sum, inequality among stayers moderately increases or remains unchanged but different types of selection bias in terms of employee turnover as a firm expands or shrinks have to be considered to interpret this result. Yet these results typically cannot explain the large overall change in wage inequality at the firm level. Instead, the previous findings suggest that the change in wage inequality within firms is mostly induced by hiring and firing and inequality among workers changes even conditional on observable and unobservable worker characteristics.

4 IV Estimation: Trade, Hierarchy and Wage Inequality

The stylized facts in the previous section raise the question whether the empirical pattern between restructuring and within-firm inequality reflects a causal effect of hierarchies on wage structure or whether a common underlying factor leads to both changes in firm hierarchies and wage patterns.

The key challenge to answer this question is that firm organization, production and wages are all simultaneously chosen by the firm. Hence, I first estimate an empirical model of organizational choice as a function of production scale motivated by the theoretical literature on firm hierarchies. I ask to what extent the positive relationship between sales and firm hierarchies reflects a causal effect of sales on organizational choice rather than production expansion in response to lower marginal costs with higher layers. Based on this model of organizational choice, I can subsequently analyze the causal relationship between hierarchies and wage inequality.

4.1 Identification Strategy

Firms that receive a positive trade shock, for example as a result of trade liberalization, can expand their scale of production. Larger scale might make a higher number of layers profitable, which then in turn lowers marginal cost of production and leads to further expansion both domestically and abroad.[21] Hence OLS regressions of firm organization on revenue or other measures of firm size will suffer from endogeneity bias. I address this issue by an instrumental variables strategy based on firm-level trade shocks following Bartik (1991) and Hummels et al. (2014) in order to estimate the role of production scale on organizational choice of the firm. In a second step, I estimate the causal effect of firm hierarchies on wage inequality using the first-stage estimates of firm hierarchies.

I exploit Danish firm-level trade data to construct firm-year-specific exogenous trade shocks. In particular, I measure trade shocks as fluctuations in world demand conditions and changes in transport costs for the products that a firm exports. Following Hummels et al. (2014), world import demand WID_{ckt} is measured as the total imports of product k to country c in period t from the rest of the world except from Denmark. Products k will be measured at the HS-6 digit level, which is the lowest disaggregation level for aggregate trade volumes from UN Comtrade. At the individual-firm level, the measure for world import demand for firm j's products at time t is then computed as the weighted average of import demand for product k at all export destination countries c

$$WID_{jt} = \sum_{k} \sum_{c} s_{jck} WID_{ckt},$$

where the product-destination weights s_{jck} reflect the importance of selling product k to a given country c relative to total export activities of firm j.[22]

Note that variation in WID at the firm level comes from the fact that different firms export different products to different destination countries and even if they sell to the same product-destination pairs, trade shares across these pairs will differ. As a result, firms will be differentially affected by changes in demand and supply conditions.

An important issue with aggregating trade shocks at the firm level is the choice of weights. Trade shares for different product-destination pairs will vary over time in response to current market conditions. In order to address this endogeneity issue, I follow Hummels et al. (2014)

[21] Following the theoretical literature on firm hierarchies, this argument is purely based on quantity expansion. A similar logic applies for quality upgrading if higher quality products require more workers and a more sophisticated firm organization.

[22] This instrument is reminiscent of Bartik (1991) instrument for changes in local labor demand; he used national employment growth weighted by local industry employment shares whereas in my analysis the aggregate level is import demand by product-destination and weights are determined at the firm level.

and use firm j's trade shares in the year before the beginning of the sample for s_{jck} in all periods t.[23] Note that introducing new products or selling old products to new destination countries will have no effect on the trade shock instrument for a given firm. In other words, if firms' production and export structure change over time, then the explanatory power of the instruments will decrease over time because these new products are not captured by pre-sample shares. The only variation used in constructing trade shocks is based on products the firm already exported in previous periods, i.e. changes at the intensive margin of trade. Yet as argued by Hummels et al. (2014), typically a large share of export revenue for Danish manufacturing firms is accounted for by a small set of stable product-destinations.[24] Hence, the instruments will be strong over time as long as the core products of a firm in the pre-sample remain an important part of their export activities in later years. Abreha, Smeets, and Warzynski (2013) lend further support to this condition because even during the Great Recession, they find that firms mostly adjusted at the intensive margin of their core products.

In addition to WID, I compute a proxy for firm-level transport costs over time, τ_{jt} using a weighted average of transport costs for all product-destination pairs of firm j,

$$\tau_{jt} = \sum_k \sum_c s_{jck} \tau_{ckt}.$$

Transport costs and mode of transportation are unobserved in the Danish trade data used in this study. Instead, I only observe product, destination country and weight information. Following Hummels (2007), I estimate a statistical model of transport costs as a function of distance traveled, oil prices and an interaction of distance and oil prices. I use the U.S. Imports of Merchandise data 1999-2006 where I observe transport costs explicitly to estimate separate coefficients by 2-digit HS product group to approximate differences in mode of transportation and sensitivity to oil price changes. This procedure yields proxies for firm-level transport costs τ_{jt} as explained in more detail in Appendix A.3.

4.2 Trade Shocks and Firm Hierarchy: First Stage and Static Model

I first employ the IV strategy to estimate the causal effect of production scale on the number of hierarchy layers. Establishing this causal link is an important step in understanding firms' organizational choice and the underlying mechanism for observed changes in firm-level inequality as firms restructure.

The goal is to estimate an empirical model of firm organization which reflects the theoretical literature on endogenous hierarchies that predicts a positive relationship between sales and

[23] If firms start exporting during my sample period, I include them in the sample starting in their second year of exporting as in Hummels et al. (2014) and I fix the trade share weights based on the initial year.

[24] The same patterns hold for U.S. exporting firms as documented by Bernard and Jensen (1999) and Bernard et al. (2007).

organization. The models by Caliendo and Rossi-Hansberg (2012) and Chen (2013) model organizational choice as a static decision and so I start from a static empirical model,

$$\text{layers}_{jt} = \alpha \log\left(\text{sales}_{jt}\right) + u_j + u_s + u_t + u_{jt} \tag{1}$$

where industry effects u_s capture for example different technologies and union power across industries and time effects u_t control for aggregate shocks. I use the the panel structure of the Danish data to include firm-fixed effects u_j to account for unobserved idiosyncratic characteristics of firms that determine hierarchies. The key parameter of interest is α, the effect of sales on hierarchy layers, which is expected to be positive according to the theoretical predictions.

Panel A of Table 7 reports the results for the static model. The first two columns provide simple OLS regressions, with firm-fixed effects added in column (2). The results show a strong positive correlation between firm organization and sales. In particular, the cross-sectional results suggest that sales for firms with one more hierarchical layer are on average twice as large. The estimate with firm-fixed effects is much smaller, but it still emphasizes a strong positive relationship between sales and organization within firms. In particular, the large difference between cross-sectional and within-firm results indicates upward bias in the cross-section because of omitted firm-level characteristics that are positively related to sales and are themselves crucial for firms' organizational choice.

Despite controlling for firm-level differences, the simple FE regression specification will still suffer from endogeneity bias because firm hierarchy and sales are jointly determined by the firm. Firm-level trade shocks provide exogenous instruments for firms' sales to analyze differences in organizational choice triggered by exogenous variation in sales. Panel B of Table 7 reports the first-stage results for the trade instruments. I estimate the first stage based on the different transport cost models discussed in Appendix A.3, and the results are similar across specifications.[25] In particular, sales are increasing in world demand for a firm's products but decreasing in transport costs. F-tests for joint significance of both instruments are highly significant for all specifications. The small standard errors for WID address concerns about measurement error in import demand for Danish products. Quality differentiation within product category might lead to increasing demand for low-quality substitutes within the same product category that will harm rather than benefit Danish exporters. Yet these confounding factors do not lead to serious measurement issues in terms of the overall relationship between sales and import demand.

Once I address the endogeneity problem using the proposed trade instruments, however, Panel A shows that the coefficient on log(sales) is not significantly different from zero and

[25] Sample size is reduced when estimating transport costs based on weight-per value (wpv) because some Danish firms export products that do not have metric weight measures in the auxiliary data set that I use to estimate the model of transport costs.

Table 7: Main Results: Static Model

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Dep Var:Layers$_t$	OLS	FE	FE-IV	FE-IV	FE-IV	FE-IV
log (Sales$_t$)	0.4398***	0.2492***	0.1314	0.1404	-0.0513	-0.0462
	(0.004)	(0.010)	(0.167)	(0.166)	(0.172)	(0.171)
Panel B: First Stage			First Stage Dependent Variable: log(sales)			
			(A)	(B)	(C)	(D)
WID			0.0332***	0.0331***	0.0355***	0.0353***
			(0.006)	(0.006)	(0.007)	(0.007)
Transport			-0.1732**	-0.1817**	-0.2683**	-0.2723**
			(0.075)	(0.075)	(0.123)	(0.120)
Obs	74,676	74,676	74,676	74,676	69,150	69,150
Firms	-	14,779	14,779	14,779	13,443	13,443
Adjusted R^2	0.457	0.799	0.931	0.931	0.931	0.931
F-Test	-	-	15.65	15.84	16.00	16.10

Notes: All regressions include industry and time fixed effects. Columns (2)-(6) further include firm-fixed effects. Clustered standard errors by firms in parentheses, *** p<0.01, ** p<0.05, * p<0.1. All F-Tests are computed based on clustered standard errors at the firm level. Columns (A)-(D) in Panel B differ in terms of the instrument for transport costs. The measures in (A) and (B) are based on the role of distance and oil prices at the HS-2 industry level. (C) and (D) use weight-per-value as an additional determinant of trade costs but do not estimate separate coefficients by industry. (B) and (D) include dummies for EU accession countries. For more details, see appendix.

even reverses its sign for some specifications. As a result, the IV estimates cannot reject the null hypothesis of sales being irrelevant for organizational choice.

Yet this result is not completely unexpected. The static model in (1) assumes that firms can choose their organizational structure every period without adjustment costs. Yet this is a very strong assumption that provides an intuitive economic interpretation of the negative finding so far. It seems likely that changes in firm organization require fixed costs in terms of search and hiring costs of adequate managers and workers, but also potentially in terms of changing the communication structure inside the firm and in terms of monitoring and incentivizing workers to follow the imposed hierarchy. As a consequence of these costs, there will be persistence in firm organization across time. In fact, this persistence in firm organization was an important feature of the stylized facts presented in Table 2. Ignoring these dynamics leads to a misspecified empirical model. As a result, the next section explicitly accounts for the dynamic nature of organizational choice.

4.3 Trade Shocks and Firm Hierarchy: Dynamic Panel Results

I extend the empirical framework to reflect adjustment costs and persistence in firms' organizational choices. In particular, I control for lagged firm organization and allow for additional limited serial correlation in the error terms,

$$\text{layers}_{jt} = \rho \text{layers}_{jt-1} + \alpha \log (\text{sales}_{jt}) + u_j + u_t + \epsilon_{jt}. \tag{2}$$

This specification recognizes the number of layers as a state variable in a dynamic optimization problem of the firm that is potentially costly to change. This type of model can be estimated using standard dynamic panel techniques following Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998). Sales are a choice variable of the firm that is jointly determined with organizational structure. The empirical model assumes that only contemporaneous sales directly affect organizational choice, whereas lagged sales only have an indirect effect through the previous number of hierarchy layers. Given these timing assumptions for sales, I can use GMM instruments to address endogeneity of sales. Alternatively, I can use the moment restrictions from firm-level trade shocks used in the previous static regressions to instrument for sales. I implement this second procedure by using predicted sales from the first stage in Table 7 and treat them as a predetermined variable in the second stage dynamic model. This two-step procedure is less efficient but also consistent under the assumptions stated above.[26] Comparing estimation results using alternative identification strategies based on GMM or trade instruments will provide a natural test for the validity of firm-level trade shocks to predict sales and organizational choices.

Table 8 reports the estimation results for the dynamic model. The first two columns provide naive specifications using OLS and FE regression without addressing the endogeneity issues because of lagged dependent variable and simultaneous firm choice of organization and production. The OLS regression in column (1) shows that the dynamic specification captures a large share of overall variation in layers because layers are highly persistent. Even within firm, sales and previous hierarchical structure have considerable explanatory power. High persistence of organizational structure motivates the subsequent use of system GMM following Arellano and Bover (1995) and Blundell and Bond (1998). In columns (3)-(5), I instrument lagged layers by the maximum available number of lags while allowing for MA(1) serial correlation in the error term and each column uses different instruments for sales respectively.[27] Column (3) only uses internal instruments for sales based on the dynamic panel

[26] In order to account for first-stage estimates being used in the second stage as regressors, I compute standard errors by running block bootstrap over the entire two-step procedure.

[27] I experimented with different MA(q) shock processes to find the most parsimonious specification that satisfies the identifying assumptions of the system GMM technique. Arellano-Bond tests for serial correlation in the regression residuals strongly reject the iid assumption; yet the assumption of an MA(1) process cannot be rejected as reported in Table 8.

Table 8: Main Results: Dynamic Panel Estimation

	(1)	(2)	(3)	(4)	(5)
Dep Var:Layers$_t$	OLS	FE	Blundell-Bond System GMM		
Layers$_{t-1}$	0.7738***	0.2792***	0.7557***	0.7459***	0.7832***
	(0.003)	(0.012)	(0.022)	(0.027)	(0.032)
log (Sales$_t$)	0.0999***	0.1960***	0.2791***	0.3278***	0.2588***
	(0.004)	(0.012)	(0.021)	(0.039)	(0.051)
IV: log (Sales$_t$)			3-max lags	WID, t	WID, t
IV: Layers$_{t-1}$	-	-	3-max lags	3-max lags	3-max lags
Transport Details				DIST, OIL by HS2	WPV, DIST, OIL
Obs	64,150	64,150	64,150	64,150	59,557
adjusted R^2	0.759	0.813	-	-	-
AB test for AR(3)	-	-	0.553	0.628	0.526
Firms	-	13,061	13,061	13,061	11,931

Notes: All regressions include time fixed effects. Columns (2)-(5) further include firm-fixed effects. Clustered standard errors by industries in parentheses for OLS and FE models, bootstrap standard errors based on 1000 repetitions using block bootstrap on firms for GMM. The Arellano-Bond test for AR(3) reports p-values. *** p<0.01, ** p<0.05, * p<0.1.

whereas column (4) and (5) first estimate predicted sales based on the trade instruments as in Table 7 and then treat sales as a predetermined variable in the subsequent system GMM estimation.

The main finding of Table 8 is a significantly positive effect of sales on organizational choice after controlling for preexisting hierarchical structure. The point estimates on the effect of sales on hierarchies differ slightly across specifications, but I cannot reject the hypothesis that the coefficients from column (3) and (4) are the same. Column (5) estimates the model for a smaller sample of firms for which I can compute weight-per-value by export product. It is reassuring that the results do not differ much for this selected group of firms.[28] In sum, firms do respond to external trade shocks and revenue shocks more generally by adjusting their organizational margin.

Since the dependent variable is the discrete number of layers, it is difficult to interpret the marginal effect of sales on organizational choice. The results suggest that the number of hierarchy layers is highly persistent, but on average a firm will only maintain its previous hierarchy if sales are sufficiently large. The higher the previous number of layers, the higher

[28] Typically, the OLS coefficient for lagged organizational form will be biased upwards if there is positive correlation of the lagged dependent variable with the time-invariant error term specific to the firm. In contrast, the dependent variable will be negatively correlated with the error term in a FE specification because the latter contains the subtracted mean error across all periods. The GMM estimates show that this downward bias is severe in this example because the dynamic panel estimates are not significantly different from the OLS estimate for lagged layers.

the estimated average sales necessary to keep a stable hierarchy, which is consistent with the stylized fact for the cross-section of firms in Figure 1.

4.4 Firm Organization and Inequality

After establishing the causal link from trade shocks and revenue to firms' organizational choices, I return to the initial question about firm hierarchies and inequality. Intuitively, different bonus payments across hierarchy layers, shifting responsibilities and changing span of control for different management layers could contribute to increasing inequality as firms add hierarchical layers.

I use the previously established empirical framework to estimate the causal link between hierarchical structure and within-firm inequality. Based on firm-level trade shocks and previous organization, I predict organizational choice and run a fixed-effects regression to estimate the relationship between firm organization and inequality,

$$\log\left(\text{sd wage}_{jt}\right) = \beta \cdot \text{predicted layers}_{jt} + \epsilon_j + \epsilon_t + \epsilon_{jt}. \tag{3}$$

Note that the approach in Equation (3) assumes that sales only affect wage dispersion within a firm through firm organization. For example, this assumption allows for systematically different bonus payments based on sales across hierarchy layers, but it assumes that for a given number of hierarchy layers, different revenue outcomes do not affect overall inequality within firm j. I will further relax this assumption in Section 6.2 below.

Table 9 shows that a higher number of layers in a given period is associated with significantly higher within-firm wage inequality in terms of the standard deviation of wages and the gap between the 90th and 10th percentile of wages.[29] In particular, an increase by one additional layer is associated with a 2.3% increase in the standard deviation of log wages and a 2.6% increase in the 90-10 log wage gap. Columns (3) to (5) reveal that the widening gap between top and bottom of the firm is mostly driven by gains at the very top relative to the rest of the firm. The interquartile range of wages within firms is practically unchanged and the increase between the 50th and 10th wage percentile is small compared to the 5.1% gain for the 90th percentile relative to the median worker at the firm. This finding is consistent with knowledge-based hierarchy theories, where firms with more hierarchical layers employ expensive top managers who can leverage their superior knowledge with the help of middle managers. The finding also relates to a recent finding by Mueller, Ouimet, and Simintzi (2015) that firm growth is particularly related to increases in the 90-50 wage gap within firms. Yet

[29] I use GMM instruments in all these regressions. I report bootstrap standard errors based on 1000 simulations using block bootstrap by firms over the entire estimation procedure to account for the first-stage estimation of layers. The regressions using the trade cost model based on distance and oil prices or the extended trade cost model including weight-per-value yield very similar results and are available from the author upon request.

Table 9: Firm Organization and Wage Inequality

	(1)	(2)	(3)	(4)	(5)
Panel A: log(wage)	log(sd wages)	log(90-10 gap)	log(75-25 gap)	log(90-50 gap)	log(50-10 gap)
layers	0.0234***	0.0258***	0.0032	0.0514***	0.0134
	(0.005)	(0.006)	(0.006)	(0.007)	(0.008)
adjusted R^2	0.515	0.551	0.527	0.579	0.512
Sample Average	0.402	0.903	0.423	0.422	0.481
Panel B: residual wages, worker controls					
layers	0.0203***	0.0293***	0.0114**	0.0486***	0.0252***
	(0.005)	(0.006)	(0.006)	(0.007)	(0.007)
adjusted R^2	0.459	0.496	0.416	0.470	0.417
Sample Average	0.322	0.74	0.382	0.394	0.345
Panel C: residual wages, worker controls and occupation FE					
layers	0.0129**	0.0207***	0.0054	0.0340***	0.0265***
	(0.006)	(0.007)	(0.007)	(0.008)	(0.008)
adjusted R^2	0.431	0.471	0.395	0.437	0.401
Sample Average	0.308	0.704	0.36	0.367	0.337
Panel D: residual wages, worker controls and worker FE					
layers	0.0183***	0.0297***	0.0040	0.0475***	0.0318***
	(0.007)	(0.007)	(0.006)	(0.008)	(0.009)
adjusted R^2	0.392	0.442	0.409	0.381	0.345
Sample Average	0.189	0.406	0.185	0.202	0.204
Observations	59,761	59,761	59,761	59,761	59,761
Firms	11,866	11,866	11,866	11,866	11,866

Notes: All regressions include industry, time and firm fixed effects. Wage residuals in Panel B-D are based on columns 3-5 of Table A.II respectively. Bootstrap standard errors in parentheses are based on 1000 repetitions using block bootstrap on firms, *** p<0.01, ** p<0.05, * p<0.1.

as I argue in more detail in the context of the Muslim boycott below, these average changes in within-firm inequality are driven by firms that decide to restructure. Hence my analysis suggests a mechanism as to why the increase in 90-50 wage gap is observed in a variety of settings with firm growth.

Interestingly, these patterns are similar when looking at residual wage inequality in Panel B-D. Additional hierarchy layers particularly increase residual wages for top managers relative to the rest of the firm, even after controlling for observable and unobservable worker characteristics. This finding is consistent with incentive-based models where observationally equivalent workers in higher layers earn more because they have a larger span of control and monitor more workers. In terms of the relative contribution to overall inequality, the sample average 90-10 wage gap for log wages is 0.903 and decreases to 0.74 (0.406) when controlling for observable (and unobservable) worker skills. The similar point estimates across the different panels in Table 9 suggest that wage inequality increases proportionately for different wage measures as firms restructure. As a result, both wage dispersion reflecting heterogeneous worker skills and pure rank differences in wages increase if a firm adds a hierarchy layer.

The stylized facts in Table 4 showed structural differences in wage setting across firms with different numbers of hierarchy layers. One more hierarchical layer was associated with a 6.3% (5.8%) higher (residual) 90-10 wage gap. Table 9 implies that about 40% (50%) of these correlation patterns can be attributed to a causal effect of the vertical organizational structure within firms.

The remaining differences in within-firm inequality cannot be explained by the four-layer vertical measure in this analysis. Firms with different vertical structures might also differ systematically with respect to the composition of different layers. For example, there might be finer vertical structures within layers that are related to wage inequality and that go undetected in the occupation-based measure of firm organization used in this paper. Moreover, firms with different hierarchies might also have very different workforce compositions within layers in terms of horizontal specialization, which could explain another important share of differences in within-firm inequality. Yet as a first approach, this paper shows the importance of the vertical dimension of firm organization and leaves the investigation of these additional aspects of firm organization for future research.

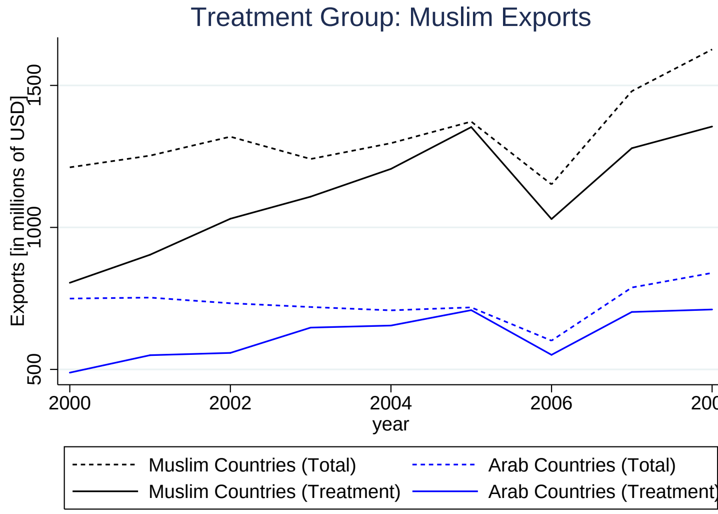
5 A Natural Experiment: Cartoon Crisis and Muslim Boycott

This section complements the previous evidence by using evidence of one well-defined trade shock for a subset of Danish exporters. In particular, I focus on the Muslim boycott of Danish products that followed the publishing of 12 caricatures of the prophet Muhammad in Denmark's largest newspaper *Jyllands-Posten* on September 30, 2005. Danish products were banned across the Muslim world starting on January 26, 2006 and the official boycott lasted several months.[30] This boycott led to a large drop in total exports from Denmark to countries with at least 50% Muslim population in 2006 as illustrated by the black dashed line in Figure 2. Overall, exports decreased by 17% to these Muslim countries, while exports to some countries such as Iran, Yemen, Kuwait and Syria that imposed official boycotts dropped by 30-50%.

This boycott provides a natural experiment to analyze the effect of a trade shock on organizational choices of firms since the boycott had long-lasting consequences for many firms. For example, in the market for dairy products in Saudi Arabia, Danish products never recovered from the shock in terms of their market share, see Antoniades (2013). The evidence in Figure 2 is consistent with this finding. Even though total exports to Muslim countries rebound in 2007 and 2008, firms in the treatment group experience a permanent decline in

[30]For a detailed time line of events see Jensen (2008) for example.

Figure 2: Danish Exports to Muslim Countries

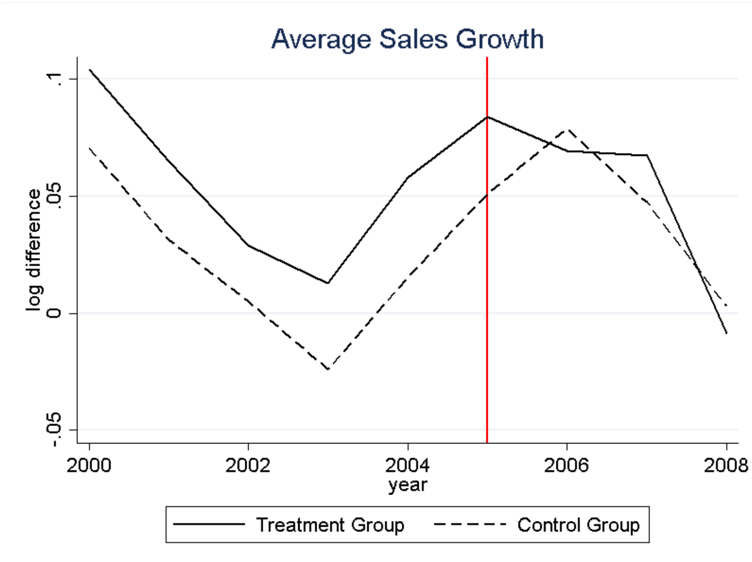


export value to Muslim destinations as illustrated by the solid lines in Figure 2. I define the treatment group as all firms in the main sample that exported to countries with more that 50% Muslim population in 2005 before the boycott.[31] The treatment group includes firms with heterogeneous degrees of exposure in terms of export shares and export volumes; this will lead to stronger implications if I find effects of the boycott even for this heterogeneous group of firms. I also use the degree of exposure to the shock as additional exogenous variation in the analysis. The control group consists of all firms in the sample without any exports to Muslim countries in 2005. I further restrict the control group to firms that exported over the period 2003-2005 to make the business environment around the shock more comparable. In 2005, I observe 1,246 firms from my main sample in the treatment group compared to 5,599 exporters that do not sell to Muslim countries.

Firms in the treatment and control group are quite different in terms of firm growth and export activities. Figure 3 shows these differences across firms by looking at average sales growth over the sample. There are stable differences in sales growth rates across the two groups until 2005 in line with the business cycle. Both groups experience a decline in sales growth during the economic downturn 2001-2003 for example. Overall, the trend until 2005 implies parallel sales growth paths. The structural break occurs from 2005 to 2006, consistent with the role of the Muslim boycott. The control group grows faster than the treatment group from 2006 onwards. In 2008, both groups suffer from negative growth rates at the beginning of the Great Recession.

[31]There is a tradeoff between using the broadest treatment group possible or focusing on firms with very large exposure. I require a minimum export share of 0.5% to Muslim destinations to focus on firms with a relevant share of business in Muslim countries, but all results are robust to using all firms with positive exports to Muslim countries in 2005. Appendix A.4.1 provides more details about the definition of the treatment group.

Figure 3: Sales Growth for Treatment and Control Group

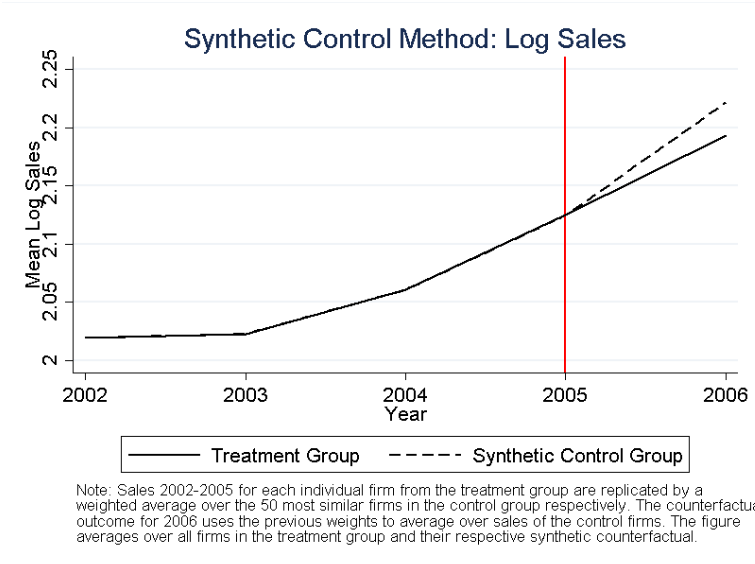


In the following, I will quantify the effect of the boycott on sales and on the probability of restructuring for firms in the treatment group and I can then use these results to measure the average change in wage inequality for firms affected by the boycott through the channel of hierarchical restructuring. Since the two groups of firms are quite different, I first present evidence on the effect of the boycott on sales by using synthetic controls analysis as first proposed in Abadie and Gardeazabal (2003). For each individual firm in the treatment group, I choose the fifty firms in the control group that are most similar in terms of sales over the period 2002-2005. I then optimally weigh these firms to create a synthetic composite firm that replicates sales of the treated firm for 2002-2005.[32] Finally, I compute counterfactual sales of the synthetic control based on these weights and actual sales of firms in the control group in 2006. Figure 4 averages over all individual trajectories and plots average log sales over time for the treatment and synthetic control group. The sales increase for firms exposed to the boycott in 2006 is much lower than predicted by the outcome for their synthetic control firms, which is an even stronger finding given the lower sales growth for the control group before the boycott in Figure 3.

Next, I run difference-in-difference specifications to estimate the effect of the cartoon crisis in 2006 controlling for industry and year fixed effects as well as firm characteristics such as lagged measures of assets, employment, sales and layers and a linear trend for the treatment

[32]I implement the method using the companion program "synth" by Abadie, Diamond, and Hainmueller (2010). I drop treated firms for which the sum of mean squared prediction errors over 2002-2005 is greater than 0.1 to focus on firms for which sufficiently similar control firms exist. I restrict the period to 2002-2006 because the method requires a balanced panel of firms in treatment and control group. As a result, I only analyze the subset of firms in the treatment group for which I observe sales for each year during this period.

Figure 4: Sales Growth for Treatment and Control Group



group to capture the trend differential suggested by Figure 3. Using data for 2000-2006 to ignore differential effects of the Great Recession, column (1) in Table 10 shows that exporters to Muslim countries experienced a significant drop in log sales growth between 2005 and 2006 relative to firms in the control group. Consistent with Figure 3, firms in the treatment group have higher average growth rates in sales over the sample period, but their growth rate decreases significantly after the boycott compared to their previous sales trajectory. This finding quantifies the graphical illustration using synthetic controls in Figure 4. Based on this evidence of differential sales growth in 2006, I estimate the effect of the Muslim boycott on organizational choices of Danish exporters. Column (2) of Table 10 shows the differential effect of the Muslim boycott on the number of layers of exporters exposed to the shock by the end of 2006. Consistent with the decrease in production scale documented in column (1), firms in the treatment group, which have a higher average number of layers than the control group over the sample period, on average significant decrease their number of layers in response to the shock.

This finding is confirmed when using linear probability models to reflect the discrete choice of restructuring. I estimate the difference in the probability of adding or dropping layers for the treatment group before and after the boycott relative to the control group of exporters that did not trade with Muslim countries to begin with. Columns (3) and (4) of Table 10 show that firms in the treatment group have a significantly lower probability to drop hierarchy layers prior to the boycott than other exporters. Yet in 2006, firms hit by the trade shock are significantly more likely to drop layers, whereas the probability of adding layers decreases compared to the control group, even though the effect on adding layers is

Table 10: Cartoon Shock and Organizational Choice

Diff-in-Diff	(1)	(2)	(3)	(4)
VARIABLES	Δ log (sales)	Δlayers	Pr(add layers)	Pr(drop layers)
T * 1{year 2006}	-0.0323**	-0.0323**	-0.0053	0.0188*
	(0.014)	(0.016)	(0.011)	(0.010)
T	0.0581***	0.0257***	0.0055	-0.0118**
	(0.006)	(0.007)	(0.005)	(0.005)
Observations	39,143	39,143	39,143	39,143
R-squared	0.063	0.118	0.082	0.060
Firms	9594	9594	9594	9594

Notes: $T = 1\{\text{Muslim Exp 2005}\}$is an indicator for the treatment group of exporters to Muslim countries in 2005. All estimation results are for the time period 2000-2006. All regressions include industry and time fixed effects as well as firm-level controls for lagged capital stock, employment, sales and layers in the previous period. Clustered standard errors by firms in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

not significantly different from zero. The coefficient estimates presented in columns (3) and (4) of Table 10 imply a significant impact of the boycott on organizational choice because overall the frequency of dropping layers in the treatment group for 2000-2005 is 10.9% and the frequency of adding layers is 10.8%. Hence the incidence of delayering (adding layers) for the treatment group increases (decreases) in 2006 by 17% (5%) relative to these benchmarks respectively. Therefore the boycott of Danish products in the Muslim world had a significant impact on Danish firms' organizational choices.[33]

The previous results measure treatment as a dummy variable to compute the average effect of the boycott on Danish exporters. However, exposure for Danish firms differs depending on the relative importance of exports to Muslim destinations before the boycott. As a result, I define exposure $E \in [0, 1]$ as the revenue share of Muslim exports in 2005 to measure heterogeneous effects of the boycott. Table 11 shows that firms with ex ante higher Muslim exports relative to total sales lost a larger percentage share of their sales, although the effect is estimated with some noise. The higher exposure in 2005, the lower the probability of delayering over the sample period, but the higher the increase in the probability to drop layers after the boycott. Moving from zero exposure to all revenue generated by exports to Muslim countries implies an increase in the probability of dropping layers by about 7 percentage points, which corresponds to an increase in the incidence of delayering by more than 60%. Similarly, the probability to add layers decreases by 4.0% for firms with maximum exposure but the effect is not precisely estimated. Including the level effect of the boycott in

[33] Placebo tests including dummies for the year 2005 in Appendix Table 3 are never significant and lend further support to the effects of the boycott. However, the point estimates for treatment effects in 2007 suggest that the boycott still had an impact on exposed firms two years later although the effects are not precisely estimated.

Table 11: Boycott Exposure and Organizational Choice

Diff-in-Diff	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Δ log (sales)		Δlayers		Pr(add layers)		Pr(drop layers)	
E * 1{2006}	-0.0607	-0.0168	-0.1322**	-0.1072*	-0.0395	-0.0400	0.0744*	0.0592
	(0.042)	(0.045)	(0.053)	(0.060)	(0.029)	(0.032)	(0.038)	(0.044)
T * 1{2006}		-0.0299**		-0.0170		0.0004		0.0104
		(0.015)		(0.018)		(0.012)		(0.012)
T	0.054***	0.058***	0.024***	0.026***	0.006	0.006	-0.011**	-0.012**
	(0.006)	(0.006)	(0.007)	(0.007)	(0.005)	(0.005)	(0.005)	(0.005)
Observations	39,143	39,143	39,143	39,143	39,143	39,143	39,143	39,143
R-squared	0.063	0.063	0.118	0.118	0.082	0.082	0.060	0.060
Firms	9,594	9,594	9,594	9,594	9,594	9,594	9,594	9,594

Notes: $T = 1\{\text{Muslim Exp 2005}\}$is an indicator for the treatment group of exporters to Muslim countries in 2005. E is boycott exposure measured as the share of exports to Muslim countries relative to total sales in 2005. All estimation results are for the time period 2001-2006. All regressions include industry and time fixed effects as well as firm-level controls for lagged capital stock, employment, sales and layers in the previous period. Clustered standard errors by firms in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

these specifications shows that these changes in firm hierarchies are entirely determined by variation in exposure as opposed to an average effect of the crisis. These patterns highlight the crucial role that trade shocks can play for organizational choices of firms.

Next, I analyze how this decrease in the average number of layers for this group of firms was reflected by changes in wage inequality. Combining the average decrease in the number of layers from column (2) in Table 10 with the results on hierarchy layers and inequality in Table 9, the model predicts an average decrease in the within-firm 90-10 wage gap for boycotted firms through the channel of restructuring of -0.08%, which is a weighted average of no effect for stable firms and a decrease in inequality for firms that decide to drop layers. Thus the average effect across firms hides a strong effect on within-firm inequality for firms that restructure. To illustrate this difference in wage inequality outcomes depending on firms' organizational response to the shock, I report changes in inequality for the treatment group in 2006 in Table 12. As expected, the average treatment effects are small and insignificant, with the largest decrease of about 2% in the 90-50 wage gap. When distinguishing changes in wage inequality by restructuring choices, I estimate a large and significant decrease in wage inequality at firms that drop layers relative to other treated firms and the control group in 2006. Dropping layers in response to the boycott goes along with a 8.8% decrease in inequality between the 90th and 50th percentile of workers in the firm. This result is consistent with the fact that most firms that drop layers decide to demote or fire some of their managers.

Finally, the matched data allow me to measure individual-level wage changes, promotions and demotions as well as job mobility for workers before and after the boycott. This exercise

Table 12: Boycott, Delayering and Wage Inequality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Δlog(90-10 gap)		Δlog(90-50 gap)		Δlog(99-50 gap)		Δlog(50-10 gap)	
T·1{year 2006}	-0.0039	0.0012	-0.0207	-0.0122	-0.0195	-0.0052	0.0144	0.0163
	(0.015)	(0.015)	(0.016)	(0.016)	(0.016)	(0.016)	(0.022)	(0.023)
T·1{2006} ·1{drop}		-0.0524		-0.0877**		-0.1475***		-0.0195
		(0.046)		(0.044)		(0.049)		(0.066)
T	0.007*	0.007*	0.002	0.002	0.022***	0.022***	0.013**	0.013**
	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)
Obs	36,386	36,386	36,386	36,386	36,386	36,386	36,386	36,386
R-squared	0.002	0.002	0.002	0.002	0.003	0.004	0.002	0.002
Firms	8,835	8,835	8,835	8,835	8,835	8,835	8,835	8,835

Notes: T = 1{Muslim Exp 2005}is an indicator for the treatment group of exporters to Muslim countries in 2005. 1{drop}is an indicator for decreasing the number of layers. All estimation results are for the time period 2001-2006. All regressions include industry and time fixed effects as well as firm-level controls for lagged capital stock, employment, sales and layers in the previous period. Clustered standard errors by firms in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

analyzes in more detail how firms restructure and it will also provide evidence on the effects on overall wage inequality. Is it the case that workers at firms that delayer simply move into similar positions at other firms keeping the overall distribution unchanged or do these workers move along the wage distribution in a systematic way to affect overall wage inequality? I conduct this analysis conditional on the occupational layer of a worker in the year 2005 and I control for second-order polynomials in age and tenure as well as education to account for differences in workforce composition that are relevant for wage growth. Column (1) of Panel A in Table 13 shows that workers at firms in the treatment group received lower wage growth 2005-2006 compared to workers employed at the control group. These differences are largest for top managers in occupational layer 4. Moreover, columns (2) and (3) show that workers in treated firms were worse off in terms of demotions and exit. Workers in supervisory layer 2 were more likely to be demoted conditional on staying at the same firm but also experienced higher exit rates than workers in similar occupations in firms from the control group. Middle managers in layer 3 mostly stayed at their firm but were most likely to be demoted. Top managers were less likely to be demoted but they had slightly higher exit rates, although not statistically significant. These average effects in Panel A again mask large differences across firms in the treatment group that are driven by firms that delayer. Panel B shows the differential outcomes for workers at treated firms that choose to delayer relative to all other employees. Top managers experience huge wage losses, all occupational groups initially employed at boycotted firms that drop layers are more likely to be demoted and to leave the company than at other firms in the sample. The wage effects are largest for top managers,

Table 13: Boycott, Delayering and Workers' Wages

	(1)	(2)	(3)
Panel A	Δlog(wage)	Pr(stay, demotion)	Pr(exit)
$T \cdot 1\{l_{2005} = 1\}$	-0.0167***		-0.0213***
	(0.001)		(0.001)
$T \cdot 1\{l_{2005} = 2\}$	0.0007	0.0046***	0.0362***
	(0.001)	(0.001)	(0.002)
$T \cdot 1\{l_{2005} = 3\}$	-0.0082***	0.0142***	-0.0124***
	(0.002)	(0.002)	(0.003)
$T \cdot 1\{l_{2005} = 4\}$	-0.0423***	-0.0233***	0.0055
	(0.013)	(0.009)	(0.012)
Obs	2,026,798	838,264	2,179,273
R-squared	0.014	0.049	0.272

Panel B	Δlog(wage)	Pr(stay, demotion)	Pr(exit)
$T \cdot 1\{l_{2005} = 1\} \cdot 1\{\text{drop}\}$	-0.0043		0.0375***
	(0.003)		(0.005)
$T \cdot 1\{l_{2005} = 2\} \cdot 1\{\text{drop}\}$	0.0039	0.0153***	0.1422***
	(0.005)	(0.003)	(0.008)
$T \cdot 1\{l_{2005} = 3\} \cdot 1\{\text{drop}\}$	0.0023	0.0276***	0.1358***
	(0.009)	(0.009)	(0.015)
$T \cdot 1\{l_{2005} = 4\} \cdot 1\{\text{drop}\}$	-0.1133**	0.2535***	0.3197***
	(0.054)	(0.050)	(0.050)
Obs	2,026,798	838,264	2,179,273
R-squared	0.014	0.049	0.272

Notes: $T = 1\{\text{Muslim Exp 2005}\}$ is an indicator that the worker was employed at a firm from the treatment group of exporters to Muslim countries in 2005. l_{2005} stand for the occupational layer of the worker in 2005. $1\{\text{drop}\}$is an indicator for decreasing the number of layers. All regressions consider the years 2005-2006. For wage changes, the sample is defined by all employees that participate in the labor market in both years. The probability of demotion is conditional on staying at the employer in 2005 for both periods and starting from at least occupational layer 2. The sample for the probability of exit includes all workers who are employed in 2005. All regressions include second-order polynomials in age and tenure as well as education as worker-level controls. The regressions for demotions and exit are linear probability models. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

which combined with the results on demotions and exits suggests that after restructuring, these workers move to a lower position along the wage distribution. As a result, overall wage inequality is reduced.

Table 14: Dynamic Panel Results: Robustness

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Domestic Firms	$\geq$5 empl	$\geq$20 empl	No Offshoring (HS 6)	Multi-plant	Multi-product
Layers_{t-1}	0.7459***	0.7708***	0.7262***	0.7356***	0.6847***	0.7601***
	(0.012)	(0.020)	(0.024)	(0.036)	(0.039)	(0.022)
$\log(\text{Sales}_t)$	0.1554***	0.2273***	0.1053***	0.1639***	0.1423***	0.2311***
	(0.009)	(0.022)	(0.033)	(0.031)	(0.046)	(0.025)
Observations	360,062	54,489	32,656	23,442	12,198	49,380
Firms	90,555	10,707	6,327	7,896	2,618	10,985
AB Test: MA(3)	0.01	0.766	0.404	0.809	0.783	0.452

Note: All regressions include time and firm fixed effects. Robust standard errors clustered at the firm level in parentheses, *** p<0.01, ** p<0.05, * p<0.1. P-values reported for Arellano-Bond (AB) test.

6 Robustness

6.1 Extensions: Trade Shocks and Hierarchies

This subsection reports several robustness checks for the effect of trade shocks on firm hierarchies. I first compare the results for the sample of exporters to all private sector firms without any international trade activities. The results are consistent with scale effects from exporting that enable firms to apply productivity gains from a higher number of layers to a larger market. Next, I address the concern that the main results are driven by changes in employment while occupations do not contain meaningful information about hierarchies. For sufficiently large firms, the probability that adding a worker will change the hierarchical structure by chance will go to zero. Hence I consider a restricted sample dropping small firms for which spurious restructuring even with purely random assignment of occupations could be an issue. Finally, I consider the role of other margins of adjustment that are not captured by the firm-specific hierarchy measure in this paper. For example, offshoring firms might change FDI as a response to trade shocks, which could counteract the production scale effect. In particular, if these firms respond to higher import demand abroad by relocating part of the firm in another country for cost-saving or market-proximity reasons, then the main results underestimate firms' organizational response to changes in production scale. Considering only exporters that do not engage in offshoring, I find a larger response to trade shocks than for the full set of exporters. In addition to that, I consider multi-product firms and multi-plant firms to see if the results are influenced by measuring hierarchical structure at the firm level as opposed to individual product lines or plants.

Consider first the results for purely domestic firms that are not engaged in any importing or exporting activities over the sample period in the first column of Table 14.[34] Compared to the main results in Table 8, the response to exogenous variation in production scale is smaller for domestic firms. This result is consistent with scale effects of exporting.[35] According to the theory in Caliendo and Rossi-Hansberg (2012) and Chen (2013), adding layers is analogous to paying a fixed cost in order to decrease marginal costs. As a result of lower marginal costs, exporting works as a multiplier to benefit from these economies of scale. Hence, exporters can increase their production even more and reap additional gains. As a consequence, exporters respond more strongly to exogenous variation in sales because they have more to gain from scale economies compared to purely domestic firms.

Consider next the results excluding small firms with less than 20 employees in column (3). This specification addresses the concern that measurement error in occupations leads to spurious adjustment of layers and therefore the main results could be biased upwards if a pure expansion in the workforce is mismeasured as an increase in hierarchy layers. Yet the larger the firm the smaller the probability of mechanical changes in the number of layers based on random assignment.[36] The estimated effect of revenue shocks on organizational choice is smaller for these larger firms; thus the true underlying response in terms of hierarchical restructuring could be smaller than reported in the main results because of measurement error. Yet the smaller coefficient is also consistent with the theory in Caliendo and Rossi-Hansberg (2012) where the range of sales for which firms choose a particular number of layers widens as the number of hierarchy layers increases. Hence if firms with 20 or more employees have a higher number of layers on average, then restructuring at these firms requires on average larger shocks and the estimated effect should be smaller.[37] This interpretation of the results is supported by the estimates for firms with at least 5 employees in column (2). The problem of measurement error should be largest for firms with less than 5 workers because mechanically, adding a worker with a different occupation will be likely to increase the number of hierarchy layers. Yet the estimated effect without these small firms is not significantly different from the results for the full set of exporters in Table 8. This is again consistent with smaller firms

[34] Given the similarity of results for different IV strategies in Table 8, Table 14 reports only specifications using GMM instruments.

[35] There are some caveats for the comparison of domestic and international firms in general. There is negative selection bias in the group of purely domestic firms as opposed to exporters. Transition patterns for domestic firms show that they are much more likely to drop layers over time and much less likely to increase the number of layers. The Arellano-Bond test for MA(3) that I never reject for exporters indicates that there is more serial correlation in residual choices of domestic firms. This is consistent with a higher weight for idiosyncratic determinants of organizational choice for domestic firms.

[36] Using the frequency of workers in the four occupational categories in the dataset, a firm with 20 employees has only a probability of 1.5% to add one layer as the firms adds one worker with randomly assigned occupation and this probability quickly goes to zero as firms become larger.

[37] In the light of this argument, the comparison between domestic firms and exporters is stronger because exporters have more layers on average and therefore are expected to show a smaller response to shocks compared to domestic firms all else equal. Yet scale economies from exporting turn out to dominate in a small open economy like Denmark such that the response is larger for exporters.

with a lower number of layers adjusting more quickly.

Finally, I consider different subsets of firms in order to understand how other margins of adjustment affect the results. First, I distinguish firms by their offshoring activities. Offshoring firms are determined using the definition of narrow offshoring from Feenstra and Hanson (1999). Firms with imports from the same 6-digit HS industry as their exported goods are considered offshoring firms. Table 14, column (4) shows that the average effect of sales on hierarchies is smaller for firms that do not engage in offshoring activities. This finding suggests that trade and foreign direct investment might play complementary rather that counteracting roles in determining firm hierarchies. I cannot measure the foreign margin of organizational adjustment but it would be an interesting extension of the present analysis to further examine the organization and location decisions for multinational firms.

Second, I can identify multi-product firms based on exports of more than one HS-6-digit product and I use establishment identifiers in the matched data to count plants for each firm. I report the results in columns (5) and (6). Multi-plant firms show a smaller response of hierarchies to revenue shocks but the standard error is quite large. The smaller coefficient estimate is consistent with multi-plant firms restructuring at a particular plant, which will not necessarily be captured by the firm-level hierarchy measure used in this analysis. If the firm already has a sophisticated hierarchy at other plants, my firm-wide hierarchy measure is unaffected by the change at one particular plant and hence adjustment of multi-plant firms is underestimated.[38] A similar argument could motivate a lower coefficient for multi-product firms as well. If an increase in sales is due to some particular product but the firm has already established a large number of hierarchy layers for other product lines, then changes in smaller product line hierarchies are likely not to be picked up by my coarse firm hierarchy variable. Yet the point estimate indicates a similar effect for multi-product firms as in the main results in Table 8. This result suggests that the four-layer hierarchies measured in this paper are typically not adjusted at the level of individual product lines but rather at the firm level. In general, it is reassuring that the results only change slightly compared to the main specification because this implies that the firm-level measure of hierarchies is a reasonable approximation that does not mask important dynamics in terms of hierarchical structure for subgroups of a firm.

6.2 Direct and Indirect Effects of Sales

Note that one of the caveats of the results in Table 9 is that sales are treated as an excluded instrument in the inequality regression (3). This assumption is violated if sales affect within-firm inequality directly conditional on hierarchy layers. This section uses dynamic panel

[38] At the same time, multi-plant firms are typically larger firms that require larger shocks to change their organizational structure, which further explains the lower point estimate.

Table 15: Firm Organization, Sales and Wage Inequality

Panel A: FE	log(sd wages)	log(90-10 gap)	log(75-25 gap)	log(90-50 gap)	log(50-10 gap)
log(sales)	0.0322***	0.0340***	-0.0082	0.0552***	0.0319***
	(0.007)	(0.007)	(0.007)	(0.008)	(0.010)
layers_t	0.0524***	0.0649***	0.0333***	0.0759***	0.0660***
	(0.005)	(0.006)	(0.005)	(0.006)	(0.008)
Obs	66,677	66,677	66,677	66,677	66,677
Adjusted R^2	0.504	0.541	0.513	0.565	0.502

Panel B: GMM	log(sd wages)	log(90-10 gap)	log(75-25 gap)	log(90-50 gap)	log(50-10 gap)
log(sales)	0.0631***	0.0783***	0.0033	0.1338***	0.0708***
	(0.017)	(0.020)	(0.019)	(0.021)	(0.026)
layers_{t-1}	0.0512***	0.0492**	0.0284	0.0463**	0.0539**
	(0.018)	(0.020)	(0.021)	(0.022)	(0.025)
Implied coefficients:					
β_1	0.0650***	0.0625**	0.0361	0.0588**	0.0684**
	(0.023)	(0.025)	(0.027)	(0.028)	(0.032)
β_2	0.0467**	0.0626***	-0.0058	0.119***	0.0536*
	(0.020)	(0.023)	(0.023)	(0.025)	(0.029)
Obs	59,090	59,090	59,090	59,090	59,090
Firms	11,818	11,818	11,818	11,818	11,818

Note: Clustered standard errors at the firm level are reported for Panel A. Standard errors for Panel B, including β_1 and β_2 use block bootstrap (200 repetitions) over the entire estimation procedure, *** p<0.01, ** p<0.05, * p<0.1.

estimation to control for the direct effect of sales on a measure of inequality using the extended specification

$$\log\left(\text{inequality}_{jt}\right) = \beta_1 \cdot \text{layers}_{jt} + \beta_2 \log\left(\text{sales}_{jt}\right) + \epsilon_j + \epsilon_t + \epsilon_{jt}. \tag{4}$$

Since layers are a function of production scale as modeled in equation (2), it is difficult to distinguish short term fluctuations in within-firm inequality related to contemporaneous sales and bonus payments from structural wage differences across firms because of different hierarchical structures. Yet rewriting equation (4) using (2) yields

$$\log\left(\text{inequality}_{jt}\right) = \beta_1 \rho \text{layers}_{jt-1} + \left(\alpha\beta_1 + \beta_2\right) \log\left(\text{sales}_{jt}\right) + \xi_{jt}. \tag{5}$$

I can estimate this equation using GMM instruments for sales and lagged layers as for equation (2) above. Based on the estimation results for ρ and α in Table 8, estimating equation (5) yields implied estimates for β_1 and β_2 that address the concern to what extent the main results are influenced by omitting sales as a control variable for within-firm inequality.

Panel A of Table 15 shows results for simple OLS regressions of equation (4) with firm-fixed effects. First, the strong positive relationship between layers and inequality as illustrated in Table 4 above also holds conditional on sales. Second, conditional on hierarchical structure, sales are positively associated with within-firm inequality except for the inter-quartile range of wages. Panel B estimates equation (5) using system GMM.[39] The elasticities of inequality with respect to sales conditional on layers are significantly positive for most inequality measures except the interquartile range. Yet the economic significance of contemporaneous sales is quite small. For example, a 10% increase in sales leads to an increase in the 90-10 wage gap by 0.7%. At the same time, one additional hierarchy layer is estimated to increase the 90-10 gap by 6.3%. In general, the estimates for the effect β_1 of hierarchy layers on inequality in this extended model are qualitatively similar to the main results in Table 9. In fact, the point estimates increase when taking the direct effect of sales on inequality into account, but the results are also not as precisely estimated as in the main specification.

In sum, the results in this section show a robust causal effect of hierarchy structure on within-firm wage inequality even allowing for direct effects of performance pay based on contemporaneous sales.

7 Conclusion

This paper has shown that firm hierarchies are an important systematic component of wage inequality and that hierarchical structure provides a new channel through which trade can affect wage inequality. Firms respond to changes in production scale by adjusting their hierarchical structure and thereby affect inequality among workers. Trade plays an important role for production scale in a small-open economy setting like Denmark and can trigger this adjustment process.

The key motivation for this paper is that wage variation across hierarchy layers within firms accounts for a systematic share of overall wage inequality, even conditional on differences in education, experience and tenure of workers in different layers. Furthermore there are broad patterns in the data between hierarchies and within-firm wage inequality. Overall, these stylized facts imply that wage inequality is higher at firms with more hierarchy layers, adding layers increases wage dispersion and wage gaps within the firm, and workers in different layers are differentially affected by changes in hierarchical structure.

The paper uses a two-step estimation strategy to analyze the new mechanism of trade on inequality through firm hierarchies. In the first step, I show the causal effect of trade shocks on firm hierarchies via changes in production scale. This finding is consistent with predic-

[39]The implied results for the underlying coefficients β_1 and β_2 are computed based on the GMM results in column 3 of Table (8) ($\rho = 0.7875$, $\alpha = 0.2515$). Standard errors are computed using 200 bootstrap repetitions over the entire two-step procedure.

tions from the theoretical literature on incentive-based and knowledge-based hierarchies that emphasize the role of production scale for organizational structure. Furthermore, the robustness section emphasizes the scale effect of exporting because exporters in general respond more strongly to revenue shocks compared to domestic firms. One caveat of the measured response in organizational choice at the firm level is that adjustments at a more disaggregated level might go undetected and hence the estimates underestimate the actual responsiveness of firms. Yet the findings for multi-product and multi-plant firms are very similar to the main results and thus support the overall strategy of this paper to measure hierarchical structure at the firm level as opposed to establishments or product lines. Moreover, exporters without offshoring activities show a similar response to firms who can also respond to shocks by adjusting foreign structures which are unobserved in this analysis. Analyzing the organizational structure of multinational firms across border is a promising research direction but it requires combining data about the same firms in different countries. Given these challenges, studying individual firms or the domestic behavior of multinationals in detail might be a promising first step to understanding interdependence of sourcing decisions and organizational choices.

In the second step of the estimation, I find a positive effect of the number of hierarchy layers on wage inequality within firms. Adding a hierarchy layer significantly increases inequality within firms, ranging from an increase of 2% for the 50-10 wage gap to 4.7% for the 90-50 wage gap. This effect is robust to controlling for direct effects of sales on wage inequality. The size of the causal effect of hierarchy layers is 40-50% of the OLS coefficient for the relationship between layers and wage inequality. Hence, this paper shows the importance of the vertical dimension of firm organization to understand within-firm inequality. But an important question is whether firms with different hierarchies also differ systematically in other dimensions than can explain the remaining correlation between organization and inequality in the data. In particular, does the coarse measure of hierarchies based on worker occupations hide finer vertical structures within firms and what is the role of horizontal specialization within layers?

The findings are corroborated by evidence for the Muslim boycott of Danish products in 2006 that led to significant delayering and a reduction in within-firm inequality among exposed firms. Worker-level evidence reveals significant wage losses for employees at firms that are exposed to the boycott. These losses are accompanied by systematic demotions and layoffs, with the largest effects for middle and top managers. Yet more work is needed to understand the consequences of these restructuring mechanisms for individual workers' career paths. More generally, a key question is how the hierarchical structure of firms interacts with career paths of workers. How are individuals trained and promoted within the hierarchical structure of their incumbent firm and to what extent do workers change hierarchical position by job mobility across firms? Integrating the analysis of individual worker careers in the framework of hierarchical firms is an important avenue for future research.

References

Abadie, Alberto, Alexis Diamond, and Jens Hainmueller (2010). "Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program". *Journal of the American Statistical Association* 105.490.

Abadie, Alberto and Javier Gardeazabal (2003). "The Economic Costs of Conflict: A Case Study of the Basque Country". *American Economic Review* 93.1, pp. 113–132.

Abowd, John M., Francis Kramarz, and David N. Margolis (1999). "High Wage Workers and High Wage Firms". *Econometrica* 67.2, pp. 251–333.

Abreha, Kaleb Girma, Valerie Smeets, and Frederic Warzynski (2013). "Coping with the Crisis: Recent Evolution in Danish Firms' International Trade Involvement, 2000-2010".

Akerman, Anders, Elhanan Helpman, Oleg Itskhoki, Marc-Andreas Muendler, and Stephen J. Redding (2013). "Sources of Wage Inequality". *American Economic Review* 103.3, pp. 214–19.

Andersen, Torben M and Michael Svarer (2006). "Flexicurity–the Danish labour-market model". *Ekonomisk Debatt* 1, pp. 17–29.

Antoniades, Alexis (2013). "Danish Cartoons, Muslim Outrage and the Response of Multi-Product Brands".

Antràs, Pol, Luis Garicano, and Esteban Rossi-Hansberg (2006). "Offshoring in a Knowledge Economy". *Quarterly Journal of Economics* 121.1.

Arellano, Manuel and Stephen Bond (1991). "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations". *Review of Economic Studies* 58.2, pp. 277–97.

Arellano, Manuel and Olympia Bover (1995). "Another look at the instrumental variable estimation of error-components models". *Journal of Econometrics* 68.1, pp. 29–51.

Autor, David H., David Dorn, and Gordon H. Hanson (2013). "The China Syndrome: Local Labor Market Effects of Import Competition in the United States". *American Economic Review* 103.6, pp. 2121–68.

Autor, David H., Lawrence F. Katz, and Melissa S. Kearney (2008). "Trends in U.S. Wage Inequality: Revising the Revisionists". *The Review of Economics and Statistics* 90.2, pp. 300–323.

Autor, David H., Frank Levy, and Richard J. Murnane (2003). "The Skill Content Of Recent Technological Change: An Empirical Exploration". *The Quarterly Journal of Economics* 118.4, pp. 1279–1333.

Bartik, Timothy J. (1991). *Who Benefits from State and Local Economic Development Policies?* W.E. Upjohn Institute for Employment Research.

Bernard, Andrew B. and J. Bradford Jensen (1997). "Exporters, skill upgrading, and the wage gap". *Journal of International Economics* 42.1-2, pp. 3–31.

Bernard, Andrew B. and J. Bradford Jensen (1999). “Exceptional exporter performance: cause, effect, or both?” *Journal of International Economics* 47.1, pp. 1–25.

Bernard, Andrew B., J. Bradford Jensen, Stephen J. Redding, and Peter K. Schott (2007). “Firms in International Trade”. *Journal of Economic Perspectives* 21.3, pp. 105–130.

Blundell, Richard and Stephen Bond (1998). “Initial conditions and moment restrictions in dynamic panel data models”. *Journal of Econometrics* 87.1, pp. 115 –143.

Bustos, Paula (2011). “Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firms”. *American Economic Review* 101.1, pp. 304–40.

Caliendo, Lorenzo, Ferdinando Monte, and Esteban Rossi-Hansberg (2015). “The Anatomy of French Production Hierarchies”. *Journal of Political Economy* 123.4, pp. 809 –852.

Caliendo, Lorenzo and Esteban Rossi-Hansberg (2012). “The Impact of Trade on Organization and Productivity”. *The Quarterly Journal of Economics* 127.3, pp. 1393–1467.

Calvo, Guillermo A and Stanislaw Wellisz (1978). “Supervision, Loss of Control, and the Optimum Size of the Firm”. *Journal of Political Economy* 86.5, pp. 943–952.

Calvo, Guillermo A. and Stanislaw Wellisz (1979). “Hierarchy, Ability, and Income Distribution”. *Journal of Political Economy* 87.5, pp. 991–1010.

Card, David E., Joerg Heining, and Patrick M. Kline (2013). “Workplace Heterogeneity and the Rise of West German Wage Inequality”. *The Quarterly Journal of Economics* 128.3, pp. 967–1015.

Chen, Cheng (2013). “Management Quality, Firm Organization and International Trade”.

Dahl, Christian M., Daniel Le Maire, and Jakob R. Munch (2013). “Wage dispersion and decentralization of wage bargaining”. *Journal of Labor Economics* 31.3, pp. 501–533.

Davidson, Carl, Steven J. Matusz, and Andrei Shevchenko (2008). “Globalization and firm level adjustment with imperfect labor markets”. *Journal of International Economics* 75.2, pp. 295 –309.

Eriksson, Tor, Valerie Smeets, and Frederic Warzynski (2009). “Small Open Economy Firms in International Trade: Evidence from Danish Transactions-Level Data”.

Feenstra, Robert C. and Gordon H. Hanson (1999). “The Impact Of Outsourcing And High-Technology Capital On Wages: Estimates For The United States, 1979-1990”. *The Quarterly Journal of Economics* 114.3, pp. 907–940.

— (2003). “Global Production Sharing and Rising Inequality: A Survey of Trade and Wages”. *Handbook of International Trade* 146.

Garicano, Luis (2000). “Hierarchies and the Organization of Knowledge in Production”. *Journal of Political Economy* 108.5, pp. 874–904.

Garicano, Luis and Esteban Rossi-Hansberg (2006). “Organization and Inequality in a Knowledge Economy”. *The Quarterly Journal of Economics* 121.4, pp. 1383–1435.

Goldberg, Pinelopi K. and Nina Pavcnik (2007). “Distributional Effects of Globalization in Developing Countries”. *Journal of Economic Literature* 45.1, pp. 39–82.

Grossman, Gene M. and Esteban Rossi-Hansberg (2008). “Trading Tasks: A Simple Theory of Offshoring”. *American Economic Review* 98.5, pp. 1978–97.

Harrison, Ann, John McLaren, and Margaret McMillan (2011). “Recent Perspectives on Trade and Inequality”. *Annual Review of Economics* 3.1, pp. 261–289.

Helpman, Elhanan, Oleg Itskhoki, and Stephen J. Redding (2010). “Inequality and Unemployment in a Global Economy”. *Econometrica* 78.4, pp. 1239–1283.

Helpman, Elhanan, Oleg Itskhoki, Marc-Andreas Muendler, and Stephen J. Redding (2012). “Trade and Inequality: From Theory to Estimation”.

Hummels, David (2007). “Transportation Costs and International Trade in the Second Era of Globalization”. *Journal of Economic Perspectives* 21.3, pp. 131–154.

Hummels, David, Rasmus Jorgensen, Jakob R Munch, and Chong Xiang (2014). “The Wage Effects of Offshoring: Evidence from Danish Matched Worker-Firm Data”. *American Economic Review* 104.6, pp. 1597–1629.

Jensen, Hans Rask (2008). “The Mohammed cartoons controversy and the boycott of Danish products in the Middle East”. *European Business Review* 20.3, pp. 275–289.

Koske, Isabell, Jean-Marc Fournier, and Isabelle Wanner (2012). “Less Income Inequality and More Growth. Are They Compatible? Part 2. The Distribution of Labour Income”.

Lemieux, Thomas (2008). “The changing nature of wage inequality”. *Journal of Population Economics* 21.1, pp. 21–48.

Mueller, Holger M., Paige P. Ouimet, and Elena Simintzi (2015). *Wage Inequality and Firm Growth*. Working Paper 20876. National Bureau of Economic Research.

PewResearchCenter (2009). “Mapping the Global Muslim Population: A Report on the Size and Distribution of the World’s Muslim Population”.

Qian, Yingyi (1994). “Incentives and Loss of Control in an Optimal Hierarchy”. *The Review of Economic Studies* 61.3, pp. 527–44.

Rajan, Raghuram G. and Julie Wulf (2006). “The Flattening Firm: Evidence from Panel Data on the Changing Nature of Corporate Hierarchies”. *The Review of Economics and Statistics* 88.4, pp. 759–773.

Smeets, Valerie, Michael Waldman, and Frederic Warzynski (2013). “Performance, Career Dynamics, and Span of Control”.

Tag, Joacim (2013). “Production hierarchies in Sweden”. *Economics Letters* 121.2, pp. 210 –213.

Verhoogen, Eric A. (2008). “Trade, Quality Upgrading, and Wage Inequality in the Mexican Manufacturing Sector”. *The Quarterly Journal of Economics* 123.2, pp. 489–530.

Williamson, Oliver E. (1967). “Hierarchical Control and Optimum Firm Size”. *Journal of Political Economy* 75, pp. 123–138.

A Appendix

A.1 Measuring Firm Hierarchies

The main empirical measurement of firm hierarchies follows Caliendo et al. (forthcoming) and focuses only on vertical hierarchy structures inside firms. In particular, the measure allows for four different organizational types, $L \in \{1, 2, 3, 4\}$ that are determined as follows:

Each worker inside a firm belongs to an occupational layer based on their reported occupation. The details of this allocation are illustrated in Table A.I. Layer 1 is considered the highest level of all occupations and only consists of directors, CEOs and general managers. The subsequent layer groups together department managers and professionals who are considered superior to technicians and associate professionals. The lowest group of occupations are white-collar and blue-collar workers who differ in their horizontal tasks inside the firm but are considered to be jointly at the lowest hierarchical level. As a result, each firm has groups of workers in one or more occupational layers as summarized in Table A.I. The main measure for the firm-level analysis will then be the number of different categories a given firm has. In

Table A.I: Occupational Layers

Layer	**DISCO**	**Description**
1	121	directors and CEOs
	131	general managers
2	100-130	all other management positions:
		senior officials, department managers
	211-213, 221-222	professionals in natural sciences
	231	higher education teaching
	240-242	business and legal professionals
	245	creative artists, designers
	247	administrative professionals
3	214	engineers
	223	nurses
	232-235	teaching (primary, secondary, special educ)
	243	archivists, information processing
	244	social sciences, translators, data analysts
	246	religious professionals
	3...	technicians and associate professionals
4	0...	military workers
	4...	clerks
	5...	services and sales
	6...	agriculture
	7...	craft and related trades
	8...	plant and machine operators and assemblers
	9...	elementary occupations

other words, a firm with two layers could consist of a general manager and some production workers or could be a group of engineers and technicians. Both firms would be considered to have similar hierarchical structure because there is only one vertical communication channel between management and workers or between engineers and technicians.

A.2 Residual Wages

Table A.II: Mincer Wage Regression

	Dependent Variable: log hourly wage				
VARIABLES	(1)	(2)	(3)	(4)	(5)
age	0.0689***	0.0689***	0.0691***	0.0671***	0.0990***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
age^2	-0.0008***	-0.0008***	-0.0008***	-0.0008***	-0.0010***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
experience	0.0275***	0.0278***	0.0232***	0.0199***	-0.0081***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
experience^2	-0.0004***	-0.0004***	-0.0003***	-0.0003***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
tenure			0.0148***	0.0130***	0.0103***
			(0.000)	(0.000)	(0.000)
tenure^2			-0.0004***	-0.0004***	-0.0003***
			(0.000)	(0.000)	(0.000)
High School	0.1749***	0.1746***	0.1732***	0.1404***	0.1988***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Vocational Training	0.1330***	0.1330***	0.1326***	0.1189***	0.4476***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
College Degree	0.3214***	0.3202***	0.3187***	0.2220***	0.3736***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Graduate Degree	0.5925***	0.5898***	0.5833***	0.3981***	0.7054***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Female	-0.1526***	-0.1530***	-0.1538***	-0.1415***	
	(0.000)	(0.000)	(0.000)	(0.000)	
Time FE	No	Yes	Yes	Yes	Yes
Occupation FE	No	No	No	Yes	No
Worker FE	No	No	No	No	Yes
Observations	15,490,963	15,490,963	15,490,963	15,490,891	15,490,963
R-squared	0.441	0.443	0.447	0.480	0.768

Notes: All regressions use all private sector employees over 1999-2008. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

A.3 Transport Cost Model

The preferred transport cost model that I estimate is

$$\log\left(\frac{\text{transport costs}}{\text{value}}\right)_{ict} = d_h + \alpha_{1h}\log\left(dist_c\right) + \alpha_{2h}\log\left(fuel_t\right) \\ + \alpha_{3h}\log\left(fuel_t\right)\log\left(dist_c\right) + \epsilon_{ict}$$

where the dependent variable is ad valorem transport cost for importing good i from country c at time t. The model estimates separate coefficients by 2-digit harmonized system (HS) product group h for distance traveled, oil prices and an interaction of these variables and includes group-specific intercepts as well. Since mode of transportation is unobserved in my data, the transport cost model is pooled over all transactions for a particular product-country pair. The intuition behind this specification is that longer distance should increase transport costs, but the effect will depend on the current oil price. As a result, firms shipping products to different destination countries will differ in terms of the burden from higher oil prices for example. Furthermore, conditional on distance, the oil price might have an effect on the choice of the mode of transportation. Hummels (2007) argues that air transport per distance is much more expensive but a decline in oil prices will make it more attractive relative to ocean shipping at the margin. Hence, the interaction of oil price and distance also captures some of the composition effects in mode of transportation. Allowing for different coefficients by HS-2 product groups takes into account that different types of products have different freight requirements and optimal modes of transportation that will changes with distance and oil prices as well.

Another insight from Hummels (2007) is that weight-per-value (wpv) in combination with distance can be considered a sufficient statistic for the mode of transportation and the importance of oil price changes on transport costs for a particular product. This is particularly useful to get a more precise measure of transport costs when the mode of transportation is not observed in the data. As a consequence, I use an alternative specification that includes weight-per-value and interactions of weight with distance and oil prices instead of group specific slope coefficients,

$$log\left(\frac{\text{transport costs}}{\text{value}}\right)_{ict} = d_h + \alpha_1\log\left(dist_c\right) + \alpha_2\log\left(fuel_t\right) + \alpha_3\log\left(wpv_{ict}\right) \\ + \alpha_4\log\left(fuel_t\right)\log\left(dist_c\right) + \alpha_5\log\left(wpv_{ict}\right)\log\left(dist_c\right) \\ + \alpha_6\log\left(wpv_{ict}\right)\log\left(fuel_t\right) + \epsilon_{ict}.$$

Finally, I experiment with extended versions of the previous transport cost models that take the expansion of the European Union into account. Since a large share of Danish trade is with European countries, accession of new members might have an important influence on transport costs. In particular, these costs also include insurance which are likely to decrease

Table A.III: Transport Cost Estimation, U.S. Imports of Merchandise 1999-2006

	Ad valorem transport costs			
VARIABLES	(A)	(B)	(C)	(D)
HS-2 specific coefficients	Yes	Yes	No	No
log(wpv)			0.209***	0.213***
			(0.0778)	(0.0778)
log(distance)	0.0428	0.0414	0.490***	0.487***
	(0.226)	(0.226)	(0.0237)	(0.0236)
log(oil price)	-1.391***	-1.392***	-0.178***	-0.182***
	(0.538)	(0.538)	(0.0581)	(0.0581)
log(wpv)·log(distance)			0.0146	0.0141
			(0.00889)	(0.00889)
log(wpv)·log(oil price)			-0.106***	-0.107***
			(0.0217)	(0.0217)
log(distance)·log(oil price)	0.174***	0.174***	0.0108	0.0115*
	(0.0637)	(0.0637)	(0.00665)	(0.00665)
log(wpv)·log(distance) ·log(oil price)			0.00892***	0.00905***
			(0.00247)	(0.00247)
Trade with new EU members after accession		-0.0301***		-0.0309**
		(0.00769)		(0.0149)
Observations	2,325,129	2,325,129	697,496	697,496
R-squared	0.188	0.188	0.258	0.259

Notes: All regressions use U.S. Imports of Merchandise data 1999-2006. Distance from the World Table and oil prices (Brent Europe) from the U.S. Department of Energy. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

after accession. The extended models include dummies for accession countries and an interaction term for accession countries after joining the EU to capture this effect. I can only estimate the effect in the U.S. data where it may or may not be as large as for Denmark but since I create a proxy for transport costs, this is still a valid approach.

I estimate these transport cost models for the U.S. Imports of Merchandise data 1999-2006 as used in Hummels (2007). This dataset has been provided for public access on the NBER data website by Robert Feenstra. I add information on distance between capitals from the World Table and data on annual oil prices (Brent Europe) from the U.S. Department of Energy, EIA. The same distance and oil price measures will be used to construct transport costs in the Danish data as well. The auxiliary dataset for the U.S. measures some commodities in square meters, by piece or in other commodity-specific units. As a result, the alternative transport cost model only includes a subset of products and hence this transport cost measure will only be available for a subset of Danish firms. Subsequently, I use the coefficients from this exercise to approximate ad valorem transport costs for each product-destination of Danish exporters, τ_{ckt} to construct the firm-level transport cost measure.

Table A.III shows the results for the different specifications based on U.S. data. The results are as expected; most importantly, transport costs increase in weight per value and in the interaction of oil price and distance. Interaction terms make computing the marginal effects of an increase in distance or oil prices cumbersome, but in the relevant range of values, transport costs increase in both of these measures in all specifications. Even for the U.S. I estimate a significant decrease in trade costs with EU accession countries after they become members of the European Union. I will project these results to Danish exporters to generate proxies for firm-specific transport costs determined by each firm's set of exported products and distance to their respective destination countries.

A.4 Details about the Cartoon Crisis

A.4.1 Definition of the Treatment Group

I define the treatment group as all firms in the main sample that exported to countries with more that 50% Muslim population in 2005 before the boycott. I require a minimum export share of 0.5% to Muslim destinations to focus on firms with a relevant share of business in Muslim countries, firms with a Muslim trade share below that threshold will be excluded and are not part of the control group. The control group consists only of firms with no export activities in Muslim countries in 2005.

The Muslim percentage of the population is based on a report from the Pew Research Center (2009) , that is based on national Census data from the years 2000-2006 and the World Religion Database using Muslim population estimates for the year 2005. The countries with more that 50% of the population Muslims are United Arab Emirates, Afghanistan, Albania, Azerbaijan, Bangladesh, Burkina Faso, Bahrain, Brunei, Djibouti, Egypt, Western Sahara, Gambia, Guinea, Indonesia, Iraq, Iran, Jordan, Kyrgyzstan, Comoros, Kuwait, Kazakhstan, Lebanon, Libya, Morocco, Mali, Mauritania, Maldives, Malaysia, Niger, Nigeria, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Sudan, Sierra Leone, Senegal, Somalia, Syria, Chad, Tajikistan, Tunisia, Turkey, Uzbekistan, Yemen, Mayotte. Since the "Cartoon Crisis" was brought to the attention of all Muslim governments during the Islamic conference in Mecca in December 2005 and because of the broad media coverage across the Muslim world, I include all of these countries in the definition of the treatment group of Danish exporters. If a Danish exporter sells at least 0.5% of exports in any of these destination countries in 2005, the firm will be part of the treatment group.

Panel A of Table A.IV shows the total number of observations in treatment and control group by year. Panel B reports the number of Danish exporters by their number of hierarchy layers based on whether they were exporting to Muslim countries in 2005 or not. The share of firms that are in the treatment group increases in the number of layers. This finding is intuitive because larger firms on average have more layers and sell to more export destinations.

Table A.IV: Number of Firms for Treatment and Control Group

Panel A: Number of observations			
Year	Control Group	Treatment Group	Total
2000	4,812	901	5,713
2001	5,690	1,108	6,798
2002	6,155	1,162	7,317
2003	6,355	1,207	7,562
2004	6,009	1,241	7,250
2005	5,604	1,258	6,862
2006	5,361	1,200	6,561
2007	4,605	1,132	5,737
2008	3,808	1,046	4,854
Total	48,399	10,255	58,654

Panel B: Trade with Muslim Countries in 2005 by Hierarchy			
#Layers in 2005	No	Yes	Total
1	951	99	1,050
2	1,429	178	1,607
3	2,050	483	2,533
4	1,174	498	1,672
Total	5,604	1,258	6,862

As a result, they are more likely to be exposed to the Muslim boycott. Nevertheless, there is also a considerable amount of Danish firms with low number of hierarchy layers exporting to Muslim countries in 2005, which makes both treatment and control group very heterogeneous.

Table A.V shows a comparison of the treatment and control group along different firm-level outcomes in 2005. The comparison shows that firms trading with Muslim countries were larger in terms of average sales, value added and employment than firms in the control group. They also exported a higher number of products to more destination countries than firms without links to Muslim countries. This difference in the composition of firms in the two groups is acknowledged in the main analysis by applying a difference-in-difference estimation approach.

A.4.2 Placebo Tests: Cartoon Crisis

Table A.VI provides a Placebo test for the boycott and adds the year 2007 to analyze lagged responses of firms in the treatment group. The coefficients for years before the boycott are never significant, but the effects in 2006 remain very similar to the main results. These specifications imply no deviation before the boycott compared to the average difference between the two groups over the entire sample period. Moreover, the point estimates for 2007 suggest a

Table A.V: Comparison for the Year 2005: Treatment and Control Group

Muslim Trade		Sales	VA	Workers	Exports	Number of Export... Dest	Prod	Prod-Dest
No	mean	11.2	2.7	39.0	1.8	5.0	10.0	21.9
	median	2.9	0.8	14.0	0.1	3.0	4.0	6.0
	sd	64.5	15.3	190.5	11.6	5.6	28.3	69.6
	p10	0.5	0.1	2.0	0.0	1.0	1.0	1.0
	p25	1.2	0.3	6.0	0.0	1.0	2.0	2.0
	p75	7.3	1.9	31.0	0.9	6.0	9.0	16.0
	p90	20.2	4.3	68.0	3.1	13.0	20.0	45.0
Yes	mean	47.3	12.1	137.6	15.0	23.8	21.2	105.2
	median	7.5	2.0	32.0	1.4	17.0	11.0	36.0
	sd	358.9	76.8	485.9	83.9	22.5	38.1	294.3
	p10	1.0	0.2	4.0	0.0	3.0	2.0	4.0
	p25	2.4	0.7	12.0	0.2	6.0	5.0	12.0
	p75	23.3	6.3	97.0	6.9	34.0	23.0	87.0
	p90	68.7	17.9	276.0	23.1	54.0	46.0	199.0

Note: Sales, value added (VA) and Exports in millions of USD (real, base year 2000)

further decrease in sales and layers, which is however not statistically significant. The results do not suggest a quick recovery of firms in the treatment group to reverse the negative effects in 2006 and are consistent with persistent losses.

Table A.VI: Cartoon Shock and Organizational Choice: Placebo Tests

	(1)	(2)	(3)	(4)
	Diff-in-Diff			
VARIABLES	Δ log (sales)	Δlayers	Pr(add layers)	Pr(drop layers)
T * 1{year 2005}	0.0059	-0.0197	-0.0061	0.0104
	(0.015)	(0.017)	(0.010)	(0.011)
T * 1{year 2006}	-0.0310**	-0.0363**	-0.0066	0.0209**
	(0.014)	(0.016)	(0.011)	(0.010)
T * 1{year 2007}	-0.0170	-0.0219	0.0006	0.0174
	(0.014)	(0.017)	(0.010)	(0.011)
T	0.0549***	0.0298***	0.0068	-0.0139***
	(0.006)	(0.008)	(0.005)	(0.005)
Observations	44,441	44,441	44,441	44,441
R-squared	0.065	0.115	0.081	0.059
Firms	9,721	9,721	9,721	9,721

Notes: T = 1{Muslim Exp 2005}is an indicator for the treatment group of exporters to Muslim countries in 2005. All estimation results are for the time period 2001-2006. All regressions include industry and time fixed effects as well as firm-level controls for lagged capital stock, employment, sales and layers in the previous period. Clustered standard errors by firms in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Economics Working Papers

2015-12:	Ina C. Jäkel and Marcel Smolka: Trade Policy Preferences and the Factor Content of Trade
2015-13:	Rene Saran and Norovsambuu Tumennasan: Implementation by Sortition in Nonexclusive Information Economies:
2015-14:	Torben M. Andersen: The Greenlandic Economy – Structure and Prospects
2015-15:	Jos Jansen: A Note on Quality Disclosure and Competition
2015-16:	Martin Paldam: The rational economist in research: A model
2015-17:	Kenneth Lykke Sørensen: Heterogeneous Impacts on Earnings from an Early Effort in Labor Market Programs
2015-18:	Leonie Gerhards and Christina Gravert: Grit Trumps Talent? An experimental approach
2015-19:	Ritwik Banerjee: On the indterpretation of World Values Survey trust question - global expectations vs. local beliefs
2015-20:	Karl Fritjof Krassel and Kenneth Lykke Sørensen: Childhood and Adulthood Skill Acquisition - Importance for Labor Market Outcomes
2015-21:	Erik Strøjer Madsen and Simon Hartington: Disruptive technologies and networking in telecom industries
2015-22:	Anders Rosenstand Laugesen: Asymmetric Monotone Comparative Statics for the Industry Compositions
2015-23:	John Kennes, Daniel Monte and Norovsambuu Tumennasan: Dynamic Matching Markets and the Deferred Acceptance Mechanism
2015-24:	Anders Rosenstand Laugesen: Extensive Margins of Offshoring and Exporting
2015-25:	John Kennes and John Knowles: Liberalization of Birth Control and the Unmarried Share of Births - Evidence from Single Mothers in the Marriage Market
2015-26:	Benjamin Friedrich: Trade Shocks, Firm Hierarchies and Wage Inequality