International Trade and Job Polarization: Evidence at the Worker Level*

Wolfgang Keller†
University of Colorado and NBER

Hâle Utar§
Bielefeld University

May 29, 2016

This paper examines the role of international trade for job polarization, the phenomenon in which employment for high- and low-wage occupations increases but mid-wage occupations decline. With employer-employee matched data on virtually all workers and firms in Denmark between 1999 and 2009, we use instrumental-variables techniques and a quasi-natural experiment to show that import competition is a major cause of job polarization. Import competition with China accounts for about 17% of the aggregate decline in mid-wage employment. Many mid-skill workers are pushed into low-wage service jobs while others move into high-wage jobs. The direction of movement, up or down, turns on the skill focus of workers' education. Workers with vocational training for a service occupation can avoid moving into low-wage service jobs, and among them workers with information-technology education are far more likely to move into high-wage jobs than other workers.

*This study is sponsored by the Labor Market Dynamics and Growth Center at the University of Aarhus. Support of the Department of Economics and Business, Aarhus University and Statistics Denmark is acknowledged with appreciation. We thank Henning Bunzel for facilitating the access to the confidential database of Statistics Denmark and for his support, William Ridley for research assistance, Anna Salomons for sending us data, David Autor and Esther Ann Bøler for their discussions, and Susanto Basu, Nick Bloom, René Böheim, Dave Donaldson, Ben Faber, Kyle Handley, Marc Muendler, Jagadeesh Sivadasan, Casper Thorning as well as audiences at the AEA (San Francisco), UIBE Beijing, JKU Linz, LSE, ZEW Mannheim, Michigan, CESifo Munich, NBER CRIW, NBER Trade, and EIIT Purdue for helpful comments and suggestions. The data source used for all figures and tables is Statistics Denmark.
†: kellerw@colorado.edu. §: haleutar@gmail.com.

1 Introduction

By integrating many emerging economies the recent globalization has led to a major increase in international trade. China, in particular, doubled its share of world merchandise exports during the 1990s before almost tripling it again during the first decade of the 21st century (World Bank 2016). During this globalization, labor markets in high-income countries became more polarized, with employment increases for high- and low-wage jobs at the expense of mid-wage jobs.[1] The top of Figure 1 shows job polarization in Denmark between the years 1999 and 2009.[2] The magnitudes are comparable to those documented for other, larger economies such as the United States. This paper examines low-wage import competition as a source of job polarization, how it affects high-income countries' labor markets, and some of the policy issues this raises.

Understanding job polarization is paramount not only because the reason for the loss of middle-class jobs matters but also because job polarization means inequality, which may adversely affect the functioning of society. In particular, if trade creates inequality it may prevent the winners and losers to agree on policies that increase total welfare–not least free trade. Using administrative, longitudinal data on the universe of workers matched to firm information between 1999 and 2009, we show that import competition has generated job polarization in Denmark—it has the unique ability, we find, to explain both the decrease in mid-wage and the increases in low- and high-wage employment.

We employ two approaches to address the key issue of causality. First, we define a worker's exposure to import competition according to the six-digit product category of the Danish economy in which the worker is active in the year 1999. The possible correlation of product-level imports with domestic taste or productivity shocks is addressed by instrumenting Denmark's imports from China with imports from China of the same products in

[1]For the case of the Unites States, see Autor, Katz, and Kearney (2006, 2008), Autor and Dorn (2013); United Kingdom: Goos and Manning (2007); Germany: Spitz-Oener (2006), Dustmann, Ludsteck, and Schonberg (2009); France: Harrigan, Reshef, and Toubal (2015) and across 16 European countries, see Goos, Manning, and Salomons (2014).

[2]The figure on top shows smoothed employment share changes for all non-agricultural occupations at the three digit occupation level that are ranked from low to high according to 1999 hourly wages. The extent of job polarization in Denmark during the early 2000s was comparable to that in the U.S. (see e.g. Autor and Dorn 2013 for the years 1980-2005). The lower part summarizes the employment share changes into three broad categories. Our definition of high-, mid-, and low-wage occupation categories is based on the mean 1999 hourly wage; see section 2 for details. The right axis shows relative average wage growth between 1999 and 2009 for the three wage categories.

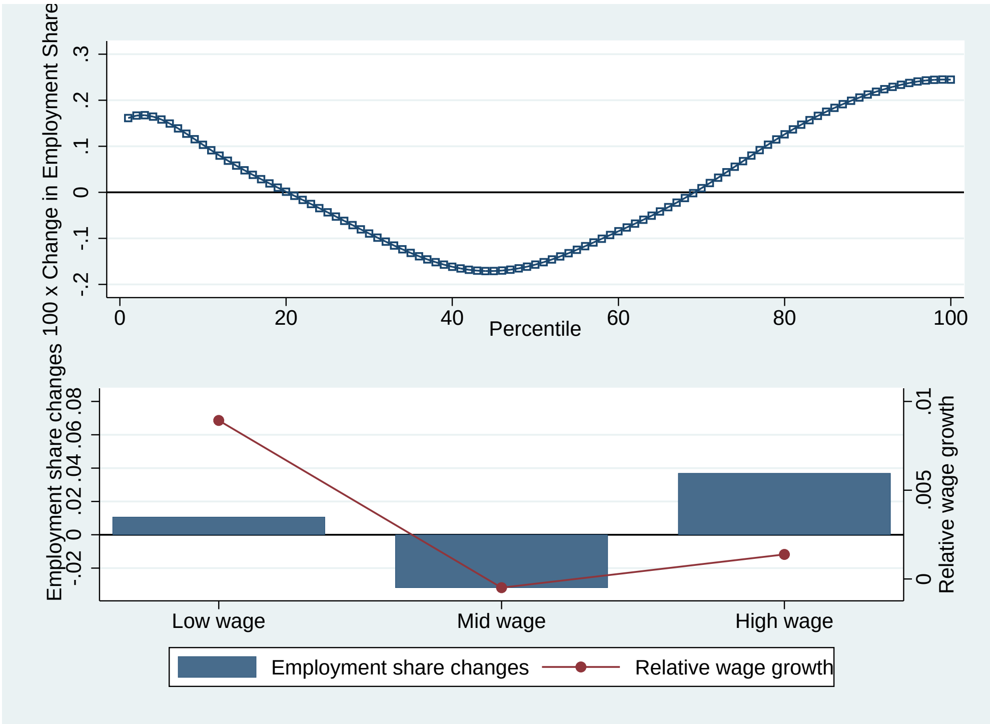


Figure 1: Job Polarization in Denmark, 1999-2009

other high-income countries. Key to this identification strategy is that the main reason for China's export growth during the 2000s is her rising supply capacity due to higher productivity and economic reforms (see Brandt, Hsieh, and Zhu 2008). It is then reasonable that China's export success in Denmark is similar to that in other high-income countries. We augment this approach by employing two openness variables as additional instrumental variables, the first based on transportation costs and the second capturing the importance of retail trade channels in a product category. Second, we present evidence from a quasi-natural experiment by studying the quota removal for textile exports as China entered the World Trade Organization (WTO).[3] Workers who manufacture narrowly defined textile products subsequently subject to quota removals are compared to workers employed at other textile-manufacturing firms. By yielding plausibly exogenous variation this trade liberalization is a quasi-natural experiment for textiles that complements our instrumental-variables results for Denmark's entire economy.[4]

[3]We use "textiles" for short; these are goods in the textiles and clothing industries.

[4]Earlier work employing the WTO textile quota removal includes Brambilla, Khandelwal, and Schott (2010), Khandelwal, Schott, and Wei (2013), Bloom, Draca, and van Reenen (2016), and Utar (2014, 2015). Our instrumental variables strategy is similar in spirit to Haskel, Pereira, and Slaughter (2007) and Autor,

Following a given set of workers has the advantage that results are not affected by re-sorting, entry, or exit, a feature that we illustrate in Figure 2 that shows employment share changes between 2000 and 2009 for three particular sets of workers. There are, first, the workers who were employed in the year 1999 in the service sector, second, the workers who in 1999 were in manufacturing, and third, the subset of manufacturing workers who in 1999 were textile workers. We see that the 1999 manufacturing workers, especially those in textiles, are strikingly important for the pattern of job polarization in Denmark. This points to import competition as a driver of job polarization, because manufacturing is relatively exposed to trade. As we will show, much of the employment increases in low- and high-wage occupations of 1999 manufacturing workers seen in Figure 2 are, in fact, in the service sector; this indicates that an analysis limited to the manufacturing sector might underestimate the importance of trade (Harrison, McLaren, and MacMillan 2011).

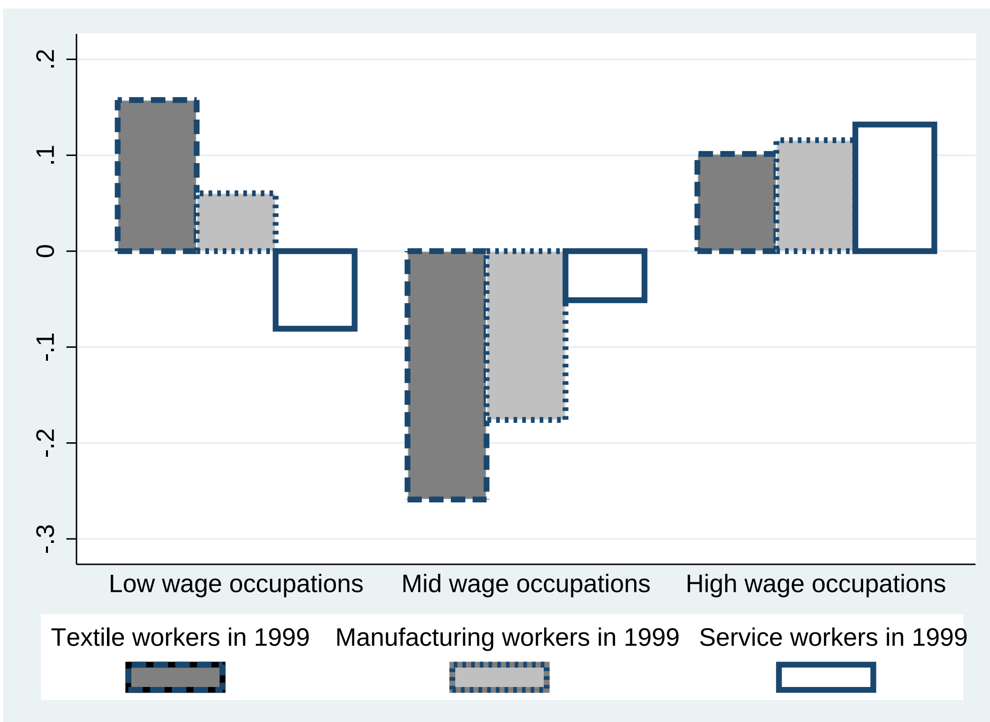


Figure 2: Changes in occupational employment share for constant sets of workers, 2000-2009

In addition to the pattern of job polarization, we are concerned with the welfare implications of trade-induced job polarization. Our analysis of occupational change is combined with

Dorn, and Hanson (2013), among others.

evidence on the workers' hourly wages in their new occupations. We show that not only does import competition lead to an important shift of workers from mid- into low-wage jobs, it also lowers these workers' hourly wage relative to other workers in the same occupations. On the positive side, import competition increases worker welfare because by shifting certain mid-wage workers into high-wage jobs it accounts for about 8% of the aggregate increase in Denmark's high-wage employment during the sample period. Import competition matters for welfare, both in terms of positive and negative effects, and overall we estimate that it accounts for about 16% of the recent increase in earnings inequality in Denmark.

Given the ubiquity of job polarization in high-income countries it is natural to think about education, whether as a way to reduce mid-wage losses or to increase the chance of mid-to-high-wage transitions. In Denmark as in many European countries vocational training of workers is common. Considered by some as the jewel of European education systems, vocational training combines formal schooling with practical apprenticeships, giving an intermediate level of education that comes in many specific forms.

One fact to be kept in mind in the policy discussion is that vocational training is important in industries with a high share of mid-wage jobs, both in manufacturing and in services (upper line and lower line, respectively, Figure 3). The relatively high share of mid-wage jobs in manufacturing on average suggests that in the past, vocational training in manufacturing has helped workers to hold on to mid-wage jobs in this sector. Vocational training may thus be seen as a successful defensive educational policy. However, if mid-wage manufacturing jobs in advanced countries are vanishing, and unlikely to return (Moretti 2012), a forward-looking educational policy will focus on training that lowers the chance of moving into low-wage, and increases the chance for high-wage jobs—does vocational training do that? Not all, it turns out, but some. We find that mid-skill workers trained for service vocations can avoid moving into low-wage service jobs, and mid-skill workers trained for information-technology vocations are far more likely to move into high-wage jobs than other workers.

In line with findings that trade with low-wage countries depresses employment and wages in exposed parts of the economy (Autor, Dorn, and Hanson 2013, Ebenstein, Harrison, McMillan, and Phillips 2014, Utar 2014, Hakobyan and McLaren, *fortcoming*, and Pierce and Schott, *forthcoming*), in this paper we show that import competition from China has adversely affected employment opportunities for much of Denmark's labor force, explaining, in particular, 17% of the decline in mid-wage employment. We show that import competition has also led to substantial high-wage employment gains. To the best of our knowledge, this is the first paper to show that import competition explains a major part of job polarization, which extends the literature explaining job polarization mostly in terms of technical change (Autor and Dorn 2013, Goos, Manning, and Salomons 2014, Michaels, Natraj, and van Reenen 2014).[5] High-wage employment gains are a manifestation of the sustained structural effects of import competition which are the focus of this paper, in contrast to the trade induced adjustment processes and frictions which are at the heart of the worker adjustment literature (Dix-Carneiro 2014, Autor, Dorn, Hanson, and Song 2014, Utar 2015). We show that import competition leads to job polarization through the shift from manufacturing towards services (especially low-wage services). Moreover, while wage polarization, shown at the bottom part of Figure 1, is quantitatively less important than employment polarization in Denmark, wage effects generally reinforce the polarizing employment effects of import competition.

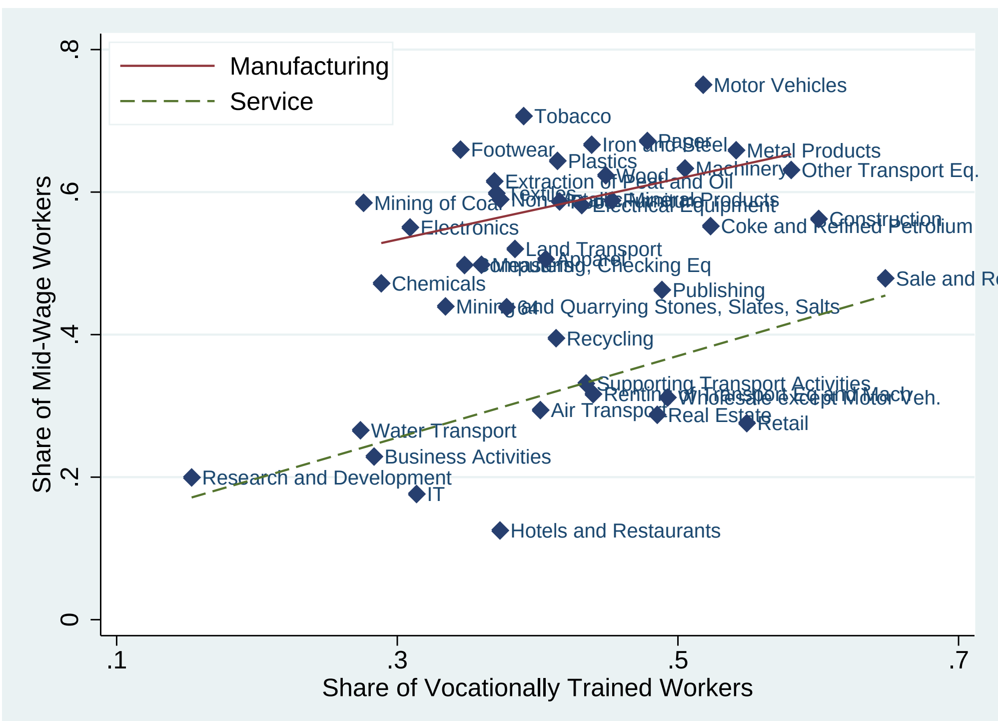


Figure 3: Mid-wage workers and vocational education

Import competition is but one factor affecting employment patterns in high-wage countries,

[5]The leading technology explanation is that computerized machines and robots replace mid-wage earning workers performing routine tasks (Autor, Katz, Kearney 2006, Goos and Manning 2007).

technical change and offshoring are others.[6] Offshoring and international trade lead to wage changes (Hummels, Jorgenson, Munch, and Xiang 2014) as well as to changes in firms' entry, exit, and innovation behavior (Bernard, Jensen and Schott 2006, Utar and Torres-Ruiz 2013, Utar 2014, Bloom, Draca, and van Reenen 2016). Comparing offshoring, technical change, and import competition side-by-side, we show that both offshoring and technical change contribute to job polarization (see Firpo, Fortin, and Lemieux 2011, and Autor, Dorn, Hanson 2015, respectively). The key new finding is that only import competition can explain the employment changes characteristic of job polarization in all three segments of the wage distribution; in contrast, offshoring and technical change cannot explain high-wage and low-wage job growth, respectively. Complementing the task analysis in Ottaviano, Peri, and Wright (2015) and Becker and Muendler (2015), our analysis differs by performing a causal analysis of job polarization, which also shows at the worker level that import competition and technical change have distinct effects. We find that import competition affects mostly workers performing manual tasks regardless of how routine intensive the tasks are.

The tri-partition of the wage distribution due to job polarization has renewed interest in educational policies targeting the middle. In particular, even though the U.S. is said to have a unique disdain for vocational education (Economist 2010), many in the U.S., including President Obama, consider now some form of vocational training to be crucial (Schwartz 2013, Wyman 2015).[7] By comparing vocationally trained workers with other workers, drawing on virtually the entire labor force of Denmark, we bring new evidence to the table on the efficacy of vocational training in the presence of a large labor demand shock. Key is our ability–based on information for about 3,000 distinct educational titles–to distinguish different forms of vocational education. Our results indicate that broadly applied vocational education may well be ineffective in protecting workers from globalization; rather, it should be targeted to particular skills that are evidently in high demand.

The next section lays out our empirical strategy, describes the data, and presents a number of facts on worker transitions between individual occupations in Denmark. Section 3 presents instrumental variables results on the role of trade for job polarization and assesses its economic magnitude. Our findings are confirmed in the quasi-natural experiment of the 2001 quota removals on Chinese textile exports in Section 4. In this context we also show worker-task level evidence on the relationship between trade and technology in causing

[6] Factors such as changing labor market institutions are seen as less important, e.g., Autor (2010).

[7] President Obama proposed making community college free to most students (Leonhardt 2015).

job polarization. Welfare and inequality implications of trade-induced job polarization are analyzed in Section 5, where we also examine educational policy options with a focus on vocational training. Section 6 provides a concluding discussion. A number of additional results are relegated to the Online Appendix.

2 Import competition and polarization: sources of variation and measurement

2.1 Import competition

To see how the rise of low-wage countries in the global economy can lead to job polarization in a high-wage country (Home), consider a framework in which Home has one traded and one non-traded goods sector. Traded goods production requires intensively tasks that are performed by workers with moderate skill levels, who are paid mid-level wages in the labor market. An increase in productivity in the traded goods sector abroad raises foreign competitiveness and exports. At Home there is an increase in the level of import competition together with a reduction in the relative demand for mid-level wage workers. Transitions from mid-level to other jobs will be shaped by the extent of wage adjustments as well as any worker- or occupation- specific adjustment costs. We ask whether import competition has caused the mid-wage employment declines and increases in both high- and low-wage employment that are typical for job polarization.

The paper employs two complementary approaches. First, following the so-called differential exposure approach (Goldberg and Pavcnik 2007), we study changes in import penetration from China across six-digit product categories. At the industry-, occupation-, or regional level the differential exposure approach has been widely applied in recent work.[8] Examining job polarization by following workers throughout the entire economy has the advantage that the effects of globalization will not be missed even if they make themselves felt outside of manufacturing. Second, we employ the exogenous shock of the dismantling of quotas on Chinese textile imports in conjunction with China's WTO accession. While the aggregate implications of the quota removal may be limited, we can investigate the causal effect of trade on job polarization in a quasi-experimental setting.

[8] See Autor, Dorn, and Hanson (2013), Kovak 2013, and Dix-Carneiro and Kovak (2015) for example.

Turning to the first approach, the change in import penetration from China is defined as:

$$\Delta IP_j^{CH} = \frac{M_{j,2009}^{CH} - M_{j,1999}^{CH}}{C_{j,1999}}. \tag{1}$$

Here, $M_{j,t}^{CH}$ denotes Denmark's imports from China in product j and year $t = \{1999, 2009\}$, and $C_{j,1999}$ is Denmark's consumption in initial year $t = 1999$, equal to production minus exports plus imports in the six-digit product category j. We address potential endogeneity by instrumenting the numerator of (1) with changes in imports from China in eight other high-income countries.[9] A key requirement for this strategy is that Chinese export success is explained to a large extent by China's increased supply capacity, which affects high-income countries' imports from China similarly, and that Chinese import growth is not driven by product-level demand shocks that are common to all advanced countries.

The relatively small size of Denmark helps because, for example, it lowers the likelihood that China's exports target a particular Danish product. To address possible sorting in anticipation of import changes, our instrumental variables approach utilizes consumption levels from the year 1996. We employ two additional instrumental variables at the six-digit level: geography-based transportation costs and a measure of the importance of retail channels. These variables are the log average of the distance from Denmark's import partners using the 1996 imports as weights, and the ratio of the number of retail trading firms over the total number of importing firms in 1996.

Figure 4 shows the change in Chinese import penetration between 1999 and 2009 across manufacturing industries versus the share of mid-wage workers in 1999. Products belonging to the same two-digit industry are given labels with the same color and shape. We see that the relationship between import penetration and the share of mid-level workers varies widely within a two-digit industry. For example, metal forming and steam generator products are both part of the fabricated metal products industry, they both have about 50% mid-wage worker, and yet the change in import penetration for steam generator products was much lower than for metal forming products. What may account for these stark within-industry differences?

[9] The high-income countries are Australia, Finland, Germany, Japan, Netherlands, New Zealand, Switzerland, and USA. To construct the variable in equation (1) we employ international trade data and business statistics data from Statistics Denmark; the instrumental variable is based on information from the United Nation's COMTRADE and Eurostat. See section 1 in the Online Appendix for details.

Despite their similarities, tasks performed by mid-level workers in occupations belonging to the same two-digit industry can in fact be quite different, and so can be worker exposure to import competition. Take "Fibre-preparing-, spinning-, and winding-machine operators" (textile machine operators for short) and "Industrial robot operators", for example, both four-digit occupations of the International Standard Classification of Occupations (ISCO, class 8261 and 8170, respectively).[10] Workers in both occupations make typically mid-level wages, and yet textile machine operators will be more negatively affected by rising import competition compared to industrial robot operators; the latter might actually experience improved employment prospects due to skill upgrading.[11] We account for these differences

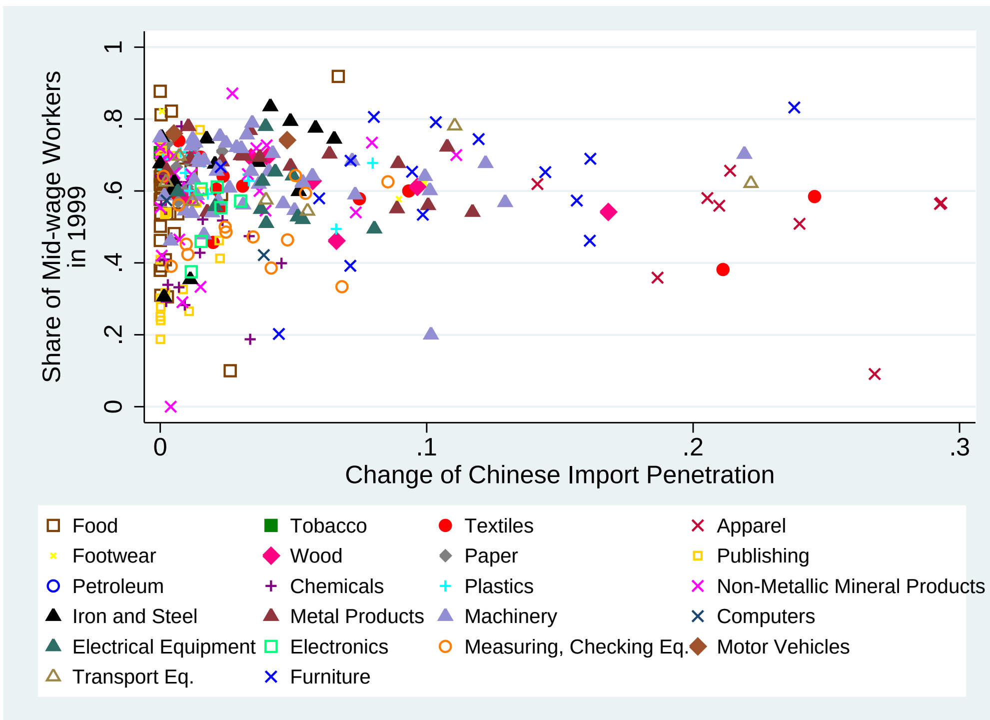


Figure 4: Mid-wage workers and import penetration from China

by including occupational fixed effects at the two- and four-digit level in the analysis.[12] Furthermore, we exploit the employer-employee link to capture technology differences in

[10]Other examples of four-digit occupations include silk-screen textile printers, textile pattern makers, tailors, bleaching machine operators, stock clerks, data entry operators, bookkeepers, accountants, secretaries, and sewing machine operators.

[11]Denmark is among the countries with the highest increase in robotization during 1993-2007 (Graetz and Michaels 2015).

[12]More than four hundred different occupations are distinguished in our analysis.

more than six hundred product categories proxied by the share of information-technology educated workers. In addition, we account for the quality level in manufacturing activity using the wage share of vocationally educated workers in the total wage bill. We also include two-digit industry fixed effects to avoid capturing differences in growth of Chinese imports across industries due to broad technological differences. As a result, we are not capturing Chinese import growth due to the potentially disproportional effect of a decline in the costs of offshoring or automatization across broader industries.

Our second definition of exposure to import competition exploits variation at the worker level due to a specific policy change, the removal of Multi-fibre Arrangement (MFA) quotas for China. The entry of China in December 2001 into the WTO meant the removal of binding quantitative restrictions on China's exports to countries of the European Union (EU); it triggered a surge in textile imports in Denmark during the years 2002 to 2009, and prices declined (Utar 2014). This increase in import competition is plausibly exogenous because Denmark did not play a major part in negotiating the quotas or their removal, which was managed at the EU level and finalized in the year 1995. Moreover, the sheer magnitude of the increase in imports after the quota removal was unexpected, and in part driven by the allocative efficiency gains in China (Khandelwal, Schott, and Wei, 2013).

We implement this approach by identifying all firms that in 1999 produce narrowly defined goods – e.g., "Shawls and scarves of silk or silk waste" – in Denmark that are subject to the MFA quota removal for China. This is our treated group of firms. The control group of firms with similar characteristics can be constructed because within broad product categories the quotas did not protect all goods. We then employ the employer-employee link provided by Statistics Denmark to obtain two sets of workers: a treatment and a control set. In the year 1999, about half of the textile and clothing workers are exposed to rising import competition. This setting affords us a way to strengthen the instrumental variables evidence with a quasi-natural experiment. Section 2 in the Online Appendix gives more information on the quota removal.

2.2 The Danish labor market

Recent work on Denmark's labor market, including Bagger, Christensen, and Mortensen (2014), Hummels, Jorgenson, Munch, and Xiang (2014), Utar (2015), and Groes, Kircher, and Manovskii (2015), indicates that the country is a good candidate for examining job polarization. In contrast to many continental European economies there are few barriers to worker movements between jobs in Denmark. Turnover as well as average worker tenure is comparable to the Anglo-Saxon labor market model (in 1995, average tenure in Denmark was 7.9 years, comparable to 7.8 in the UK). Hiring and firing costs are low in Denmark. This is confirmed by more recent international comparisons: for example, in the 2013 Global Competitiveness report, Denmark and the US are similarly ranked as 6th and 9th respectively in terms of flexibility of hiring and firing regulations.

The flexibility in terms of firing and hiring practices is combined with a high level of publicly provided social protection. Most Danish workers participate in centralized wage bargaining, which tends to reduce the importance of wages in the labor market adjustment process. However, in recent years decentralization in wage determination has increased wage dispersion (Eriksson and Westergaard-Nielsen 2009). While we find that occupational shifts are central to explaining polarization in the Danish labor market, our earnings and hourly wage results are consistent with significant wage effects in Denmark in response to globalization, as documented by Hummels, Jorgenson, Munch, and Xiang (2014).

2.3 Worker- and firm data

The main database used in this study is the Integrated Database for Labor Market Research of Statistics Denmark, which contains administrative records on individuals and firms in Denmark.[13] We have annual information on all persons of age 15 to 70 residing in Denmark with a social security number, information on all establishments with at least one employee in the last week of November of each year, as well as information on all jobs that are active in that same week. These data files have been complemented with firm-level data and international transactions to assess exposure to import competition, as well as information on domestic production which we employ in the quota removal analysis.

The worker information includes annual salary, hourly wage, industry code of primary employment, education level, demographic characteristics (age, gender and immigration status), and occupation of primary employment.[14] Of particular interest is the information on workers' occupation. Occupational codes matter in Denmark because they influence earnings due

[13]See Bunzel (2008) and Timmermans (2010) for more information.

[14]Employment status is based on the last week in November of each year. Thus our results will not be influenced by short-term unemployment spells or training during a year as long as the worker has a primary employment in the last week of November of each year.

to the wage determination system. Because employers and labor unions pay close attention to occupational codes, data quality is high compared to other countries.[15] As noted above, occupation codes are generally given at the four-digit level of the ISCO-88 classification which allows us to distinguish more than four hundred detailed occupations.

Table 1: Summary Statistics, Economy-wide Sample (n=900,329)

	Mean	Standard Deviation
Panel A. Outcome Variables		
Cumulative Years of Employment in High Wage Jobs (2000-2009)	2.638	3.689
Cumulative Years of Employment in Mid Wage Jobs (2000-2009)	3.581	3.755
Cumulative Years of Employment in Low Wage Jobs (2000-2009)	1.281	2.457
Panel B. Characteristics of Workers in 1999		
Age	34.093	8.852
Female	0.339	0.473
Immigrant	0.045	0.208
College Educated	0.176	0.381
Vocational School Educated	0.436	0.496
At most High School	0.377	0.485
Years of Experience in the Labor Market	12.868	6.205
History of Unemployment	1.025	1.716
Log Hourly Wage	5.032	0.448
High Wage Occupation	0.265	0.441
Mid Wage Occupation	0.509	0.500
Low Wage Occupation	0.194	0.395
Union Membership	0.762	0.426

Notes: Variables Female, Immigrant, Union Membership, Unemployment Insurance (UI) Membership, High Wage, Mid Wage and Low Wage Occupations, College Educated, Vocational School Educated and At most High School are worker-level indicator variables. History of Unemployment is the summation of unemployment spells of worker i until 1999 (expressed in years). Values are reported throughout the paper in 2000 Danish Kroner.

Our sample of n = 900,329 workers are all who were between 18 and 50 years old in 1999 and employed in a firm operating in the non-agricultural private sector for which Statistics Denmark collects firm-level accounting data. By holding constant this sample of workers and follow them as they change jobs and sectors, our results are not affected by factors that lead to entry or exit of workers, including immigration.[16] The age constraint ensures that

[15] Groes, Kircher, and Manovskii (2015) emphasize this point.

[16] For example, as a result of the increase in refugees in Denmark starting in the mid-1990s, the employment

workers are typically active in the labor market throughout the sample period, and firm-level accounting information is needed for a number of covariates. As of base year 1999, workers were employed in a wide range of industries, including mining, manufacturing, wholesale and retail trade, hotels and restaurants, transport, storage and communication, as well as real estate, renting and business activities.[17] As in most high-income countries, the sectoral composition of the sample during this time changed from manufacturing (going from 33% of the sample in 1999 to 20% by 2009) towards services.

Following the literature on job polarization we distill the U-shaped pattern into changes for three separate groups, called low-, mid-level, and high-wage workers (Autor 2010, Goos, Manning, and Salomons 2014). We form these groups based on the median wage paid in an occupation in Denmark for the year 1999.[18] The high-wage occupations comprise of managerial, professional, and technical occupations. Mid-wage occupations are clerks, craft and related trade workers, as well as plant and machine operators and assemblers. Finally, low-wage occupations include service workers, shop and market sales workers, as well as workers employed in elementary occupations. Descriptive statistics for the sample are reported in Table 1. Panel A provides information on the employment trajectories of the workers between 2000 and 2009. On average across all workers, the number of years spent in mid-wage occupations was about 3.6 years. This is one of our outcomes variables, defined as

$$MID_i^e = \sum_{t=2000}^{2009} Emp_{it}^m, \tag{2}$$

where Emp_{it}^m is an indicator variable that takes the value of one if worker i has held a primary job in mid-level wage occupations in year $t \in T$ ($T = \{2000, ..., 2009\}$). The variable MID_i^e ranges from a maximum of 10 years for a 1999 mid-wage worker who has been employed in mid-wage occupations throughout the years 2000 to 2009, to a minimum of 0 for an 1999

share of Non-European Union immigrants increased from 2.5 to 4.5 % until the mid-2000s; see Foged and Peri (2016) for a study of the impact of refugees on native worker outcomes in Denmark.

[17]Sectors that are not included as initial employment of workers in the sample are mainly public administration, education, health, and a wide range of small personal and social service providers. Education and health sectors in Denmark are to a large extent publicly owned. We have also employed a larger sample including the public sector with about 1.5 million observations, finding that this does not yield important additional insights.

[18]We rank occupations at the one-digit level for full-time workers (see Table A-1). An advantage of classifying major occupations is that the mapping of occupations into high-, mid-, and low wage categories does not change throughout the sample period. Employing the classification of Goos, Manning, Salomons (2014) based on the 1993 wages at the two-digit ISCO across European countries including Denmark leads to very similar results.

high- or low-wage worker who never had a spell in mid-wage jobs. MID_i^e takes higher values if worker i was employed in a mid-wage occupation in 1999 and stayed in his or her job, or if worker i was initially employed in high- or low-wage occupations but transitioned into a mid-wage occupation relatively early. Occupational change within the category of mid-wage occupations is not picked up by this variable. Analogously, we define LOW_i^e and $HIGH_i^e$ as the cumulative low-wage and high-wage employment of worker i between the years 2000 and 2009.

The percentage of workers with college education is 18%, 44% of workers have formal vocational training, and the remaining 38% workers have at most high school education. In Denmark vocational education is provided by the technical high schools (after 9 years of mandatory schooling) and involves several years of training with both schooling and apprenticeships. As typical of many European countries our sample has a relatively high share of vocationally-trained workers.[19]

For the textile worker sample that will be employed in the quota removal analysis, summary statistics are shown in Table 2. We focus on workers who are of working age throughout our sample period, about 10.5 thousand workers.[20] Compared to the economy as a whole, as typical of manufacturing in general, mid-wage occupations are relatively more important (66% of textile workers hold mid-wage occupations in 1999).

[19]The shares of college, vocational, and at most high school education for Denmark as a whole in 1999 are quite similar to those in our sample; the former are 25%, 43%, and 32%, respectively.

[20]Since this sample is smaller our age limits are less conservative. Workers are between 17 and 57 years old in 1999, which ensures that they will typically be active in the labor market between 2002 and 2009.

Table 2: Summary Statistics, Textile Sample (n=10,484)

	Mean	Standard Deviation
Panel A. Outcome Variables		
Cumulative Years of Employment in High Wage Jobs (2002-2009)	1.366	2.498
Cumulative Years of Employment in Mid Wage Jobs (2002-2009)	2.545	2.840
Cumulative Years of Employment in Low Wage Jobs (2002-2009)	1.010	1.985
Panel B. Characteristics of Workers in 1999		
Age	39.663	10.358
Female	0.569	0.495
Immigrant	0.061	0.240
College Educated	0.123	0.329
Vocational School Educated	0.352	0.478
At most High School	0.509	0.500
Years of Experience in the Labor Market	14.729	5.783
History of Unemployment	1.292	1.828
Log Hourly Wage	4.964	0.374
High Wage Occupation	0.205	0.404
Mid Wage Occupation	0.664	0.472
Low Wage Occupation	0.119	0.324
Union Membership	0.822	0.383

Textiles is a typical manufacturing industry in which plant and machinery operators, who typically earn mid-level wages, are important; according to Figure A-1, they account for more than 40% of all workers. Nevertheless the textile industry employs workers performing a diverse set of tasks. Other occupations accounting for about 10% of the labor force include technicians and associate professionals, craft workers, as well as clerks. Managers at various levels account for about 5% of all workers; see Figure A-1. Comparing the distribution of occupations in the exposed firms with that in the non-exposed firms, we see that plant and machine operators is the largest occupation in both sets of firms and there does not appear to be major differences between the two sets of firms in panel (b) of Figure A-1. Given their importance, examining the group of machine operators in detail, Table A-2 reports that the vast majority of sewing machine operators both in exposed and non-exposed firms were women, 96 and 95 % respectively, while among weaving and knitting operators both in the exposed and non-exposed group of workers, the average worker was a 41 year old man with a labor market experience of about 16 years and a history of unemployment equivalent to one year.

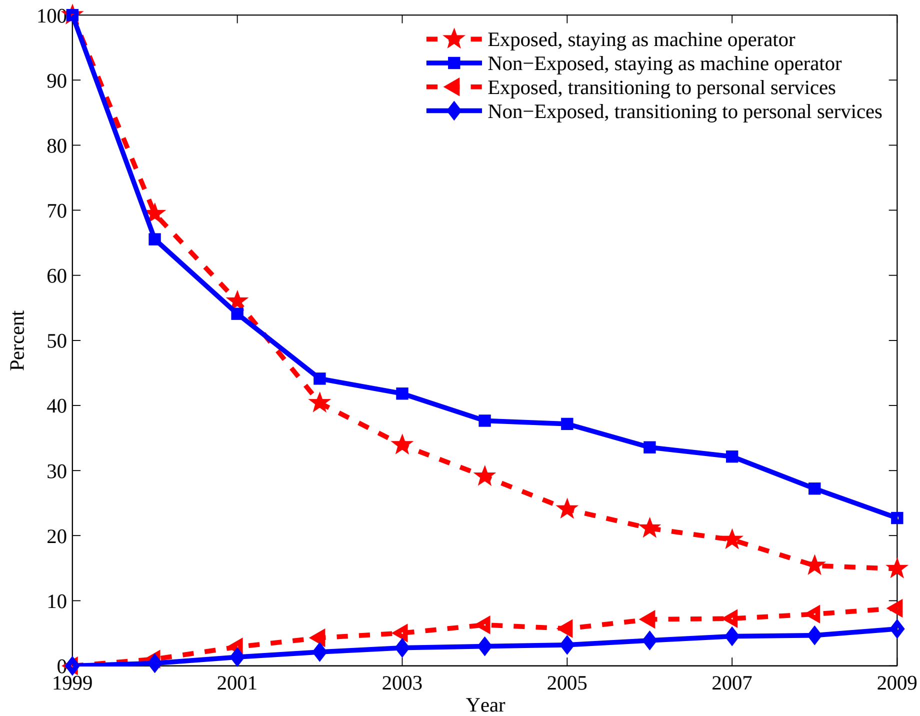


Figure 5: Occupational Transition Probabilities of Textile Machine Operators by Exposure To Competition

If import competition causes job polarization, mid-wage employment reductions and high- and low-wage increases must be relatively pronounced for workers who are employed in 1999 in firms that subsequently are affected by the quota removal. Figure 5 provides some initial evidence on this by comparing the job transitions of treated and untreated machine operators and assemblers (ISCO 82; machine operators for short). Consider first the hollowing out of mid-wage employment. Because we start with the universe of machine operators in 1999 and do not include post-1999 entrants, the two upper lines in Figure 5 start at 100% and slope downward over time. The chief observation is that the rate at which machine operators leave their occupation in exposed firms is considerably higher than the rate at which they leave it in non-exposed firms. To be sure, the pattern of Figure 5 suggests that demand for machine operator services has declined for a number of reasons (such as technical change). At the same time, in 2009 only about 15% of the exposed machine operators are in that same occupation, which compares to about 23% machine operators that remain in their original occupations conditional on not being exposed to rising import competition.

Turning to increases in low-wage employment, the two lower lines in Figure 5 give the cumulative probabilities of machine operator transitions to personal and protective services (ISCO 51). This is a low-wage occupation that includes the organization and provision of travel services, housekeeping, child care, hairdressing, funeral arrangements, as well as protection of individuals and personal property. Occupations such as these have played a major role in the polarization of the U.S. labor market (Autor and Dorn 2013). Figure 5 shows that the movement of exposed machine operators into personal and protective service jobs is considerably more pronounced than for non-exposed machine operators. By the year 2009, about 9% of the original exposed machine operators are in the personal and protective service occupation, compared to about 6% of the non-exposed machine operators. This evidence is in line with findings of a recent strengthening of trade effects in larger and less open economies such as the U.S. (Autorn, Dorn, and Hanson 2015). Consistent with job polarization, workers exposed to rising import competition move relatively strongly from mid-wage into low-wage occupations. It is also interesting that the extent to which exposed workers move more noticeably away from mid-wage and towards low-wage jobs than non-exposed workers is quite similar (about 50%). The movement away from mid-wage and towards low-wage jobs seems to be driven by the same factor: namely, import competition. A similar figure for high-wage occupations (not shown) suggests that exposed workers move also more strongly than non-exposed workers into high-wage occupations.

If a given exposed worker leaves his or her occupation the worker will typically take a job in either a high or a low-wage occupation, not in both. In our sample with more than 900,000 observations, more than 95% of the 1999 mid-wage workers either stay in that wage category or move either up or down for any amount of time during 2000-2009. Of all workers that had mid-wage occupations in 1999, 22% had high-wage employment and 21% had low-wage employment during the years 2000-2009. What about these figures for 1999 mid-wage workers exposed to rising import competition? For those, the share of workers with high-wage employment during 2000-2009 is 19%, whereas the share with low-wage employment during the same time is 25%.[21] Thus import competition is associated with a decline in transitions to high-wage occupations and an increase in transitions to low-wage occupations.

[21] Strongly exposed is defined here as a worker at the 90th percentile in terms of Chinese import competition.

3 Import competition causes economy-wide polarization

3.1 Chinese Imports and the Decline in Mid-Wage Jobs

To shed light on the factors that influence the relationship between import competition and mid-wage jobs we proceed in steps and estimate several versions of the following equation

$$MID_i^e = \alpha_0 + \alpha_1 \Delta IP_j^{CH} + Z_i^W + Z_i^F + Z_i^N + \epsilon_i, \tag{3}$$

where Z_i^W are worker- , Z_i^F are firm-, and Z_i^N are product level variables. The change in Chinese import penetration, ΔIP_j^{CH}, is instrumented as described in section 2.1. The sample consists of $n = 900,329$ workers.

The first specification employs Chinese import competition, captured by ΔIP_j^{CH}, together with two-digit industry fixed effects. At the bottom of Table 3 the first-stage F-statistic of about 12.5 (p-value of virtually 0) shows that our instrumental variables are predictive of the change in Chinese import competition. First-stage coefficients are significant and of the expected sign; they are shown in the Online Appendix, Table B-4. The second stage coefficient is negative.

The import competition coefficient moves closer to zero with the inclusion of age, gender, immigration status and education indicators (column 2). Furthermore, worker experience, unemployment history, hourly wage, and workers' two-digit occupation help to bring the Chinese import competition estimate to -6.8 (column 3). Thus, mid-wage employment declines can to some extent be accounted for by the composition of the workforce in exposed versus not exposed parts of the economy. All coefficients are shown in the Online Appendix, Table B-4.

The specification in column 3 compares implicitly workers with similar demographic and education characteristics, wages and employment experiences, occupations, and industry characteristics, some of whom are employed in producing six-digit product categories exposed to rising import competition while others are not. Because firms can be important in formulating the response to import competition (Utar 2014, Bloom, Draca, and van Reenen 2016), we condition on the most salient firm characteristics in this context, size, quality, and the extent to which workers separate from their firms. These firm variables do not change the import competition estimate much (column 4).

Mid-wage employment is likely to be affected by the adoption of new information and communication technologies (ICTs). To capture this we include the share of information technology-educated workers for each of the roughly 600 product categories. Furthermore, we add the wage share of vocationally trained workers. The coefficient for Chinese import competition is now estimated at about -5.3 (column 5). This is less than half the size of the effect in column 1, underlining the importance of the worker-, firm-, and product variables that we employ.

The performance of the instrumental variables does not change much with the inclusion of worker, firm, and product-level variables. In particular, the first-stage F-statistic is similar, and the over-identification tests present no evidence that the instrumental variables are not valid. The final column in Table 3 shows OLS results for comparison. The Chinese imports variable has a negative point estimate close to zero. This is consistent with the hypothesis that import demand from China is positively correlated with industry demand shocks, and failing to account for this correlation, the OLS estimate is upwardly biased.

3.2 Can trade explain the U-shaped job polarization pattern?

This section asks whether rising import competition leads to employment increases in the high- and low-wage tails of the distribution. Without these increases one cannot conclude that import competition causes job polarization.

We begin with employment in high-wage occupations. The dependent variable is $HIGH_i^e$, the cumulative number of years that worker i has worked in high-wage occupations during 2000-2009. Otherwise the specification is identical to the regression of Table 3, column 5 (presented again for convenience in Table 4). We see that workers exposed to rising Chinese import competition have more employment in high-wage jobs than otherwise similar workers that are not exposed. We also see that workers exposed to import competition have more low-wage employment than not exposed workers (column 3). Overall the results show that rising import competition from China has caused job polarization in Denmark.

Table 3: Import Competition and Decline in Mid-wage Jobs

	Cumulative Mid-wage Employment					
	MID^e	MID^e	MID^e	MID^e	MID^e	MID^e
	(1)	(2)	(3)	(4)	(5)	(6)
	IV	IV	IV	IV	IV	OLS
Δ Imports from China	-12.072*	-9.600*	-6.787*	-6.956*	-5.273*	-0.025
	(6.101)	(4.857)	(3.202)	(2.913)	(2.282)	(0.660)
Demographic Characteristics	no	yes	yes	yes	yes	yes
Education Characteristics	no	yes	yes	yes	yes	yes
Hourly Wage	no	no	yes	yes	yes	yes
Labor Market History	no	no	yes	yes	yes	yes
Two-digit ISCO Occupation FE	no	no	yes	yes	yes	yes
Union and UI Controls	no	no	yes	yes	yes	yes
Firm Characteristics	no	no	no	yes	yes	yes
Product Characteristics	no	no	no	no	yes	yes
Two-digit Industry FE	✓	✓	✓	✓	✓	✓
N	900,329	900,329	900,329	900,329	900,329	900,329
Number of clusters	170	170	170	170	170	170
First-stage F-test	12.556	12.567	12.567	12.397	12.570	
First-stage F-test [p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	
Hansen J p-value	0.690	0.731	0.791	0.938	0.872	

Notes: Robust standard errors clustered at the 3-digit industry level in parentheses. Demographic variables are age as well as indicators for gender and immigration status. Education indicator variables: At least some college, vocational education, and at most high school. Wage is the logarithm of i's average hourly wage. Labor market history variables: the sum of the fraction of unemployment in each year since 1980, the number of years of labor market experience before 1999, and number of years squared. Union and unemployment insurance (UI): indicator variables for membership status in year 1999. Firm variables: size, measured by the number of full-time equivalent employees, quality, measured by the log of average hourly wage paid, and strength of firm-worker relationship, measured by the separation rate between years 1998 and 1999. Product-level variables: size, measured by the log number of employees in 1999, information technology (IT) skills, as the share of workers with IT education, and importance of lower-level technical skills, measured by the wage share of vocationally trained workers, all in 1999. Further product-level variables: the percentage change in employment over years 1993-1999 as a pre-trend control, average annual growth of energy usage, and retail employment growth where worker i's manufactured product is sold, both over years 2000-2008. Excluded instrumental variables at the six-digit product level: the change in Chinese import penetration in eight high-income countries, the log average distance of each product's import sources, using 1996 imports as weights, and the share of trade firms importing directly in 1996. $^{\circ}$, * and ** indicate significance at the 10 %, 5% and 1% levels respectively.

Table 4: Is the hollowing out of the middle accompanied by gains in the tails?

	MID^e	$HIGH_i^e$	LOW^e	JP^e	JP^{hrs}	JP^{earn}
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Imports from China	-5.273*	2.307*	2.369*	9.950**	10.095*	11.536°
	(2.282)	(1.075)	(1.178)	(3.741)	(3.971)	(6.693)
Demographic Characteristics	yes	yes	yes	yes	yes	yes
Education Characteristics	yes	yes	yes	yes	yes	yes
Hourly Wage	yes	yes	yes	yes	yes	yes
Labor Market History	yes	yes	yes	yes	yes	yes
Two-digit ISCO Occupation FE	yes	yes	yes	yes	yes	yes
Union and UI Controls	yes	yes	yes	yes	yes	yes
Firm Controls	yes	yes	yes	yes	yes	yes
Product Characteristics	yes	yes	yes	yes	yes	yes
Two-digit Industry FE	yes	yes	yes	yes	yes	yes
Number of Observations	900,329	900,329	900,329	900,329	879,614	900,329
Number of clusters	170	170	170	170	170	170
First-stage F-test	12.570	12.570	12.570	12.570	12.579	12.570
First-stage F-test [p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Estimation by two stage least squares. Robust standard errors clustered at the 3-digit industry level in parentheses. All specifications include demographic (gender, age, immigration status), education, hourly wage, labor market history (unemployment history, linear and square terms of experience), union and unemployment insurance memberships, firm (size, wage, separation rate), as well as product-level covariates as described in Table 3. All specifications also include two digit occupation fixed effects and two-digit industry fixed effects. °, * and ** indicate significance at the 10 %, 5% and 1% levels respectively.

To assess economic magnitudes we compare two workers, one at the 10th and the other at the 90th percentile of exposure to import competition. The difference in the change in Chinese import penetration for these workers is 0.037. With a coefficient of about -5.3 in column 1, a highly exposed worker has typically just under 0.2 years of mid-wage employment *less* than the typical not exposed worker.[22] The coefficients in columns 2 and 3 translate into about 0.09 years *more* of high-wage and low-wage employment each. Because the sum of the trade-induced employment effects across all three wage categories is close to zero, movements outside of the labor market (long-term unemployment, training) do not affect these results much.

To put this in perspective, a worker with a bad unemployment history for example has usually 0.4 years less mid-wage employment between 2000 and 2009 than a worker with a good unemployment history, and a 47 years old worker has typically 0.5 years less mid-wage employment than a 22 years old worker. A worker employed in a large firm (500 or more employees) has 0.06 years more high-wage employment over ten years than a worker employed in a smaller firm with five employees. These figures suggest that globalization has sizable effects.

While the finding of negative globalization effects for some workers is not new, the result that, through the transitioning of workers into higher-wage occupations as well as into low-wage occupations, import competition leads to job polarization is, to the best of our knowledge, novel. The benefits from moving into high-wage occupations are independent from other positive welfare effects of globalization, for example through lower goods prices.

To facilitate some of the exposition in the following, we define a polarization measure that simultaneously captures employment increases in the tails and decreases in the middle. Let JP_i^e be defined as the sum of years of employment in high- and low-wage occupations, minus years employed in mid-wage occupations, over the period 2000 to 2009:

$$JP_i^e = HIGH_i^e + LOW_i^e - MID_i^e, \ \forall i \ . \tag{4}$$

This variable gives equal weight to employment increases in the tails and decreases in the middle. By construction, the coefficient on Chinese imports in the regression with JP_i^e as the dependent variable is equal to the sum of the absolute values of the coefficients with $HIGH$,

[22]If we focus on the 90/10 exposure difference for manufacturing workers, the effect becomes larger, namely 0.42 years.

MID, and LOW as the dependent variables (see Table 4, columns 1 to 4). Analogously, we define an hours worked variable as

$$JP_i^{hrs} = HIGH_i^{hrs} + LOW_i^{hrs} - MID_i^{hrs},\ \forall i \tag{5}$$

where $HIGH_i^{hrs}$ is the number of hours that worker i was employed in high-wage occupations during the period 2000-2009, relative to initial annual hours worked by worker i; MID and LOW are defined analogously. Employing this measure we see that the impact of Chinese import competition on hours worked is quite similar to that for years of employment (column 5, compared to 4). This suggests that the more permanent movements captured by the years of employment variable describe the job polarization experience quite well.

By analyzing polarization in terms of years and hours of employment we have so far focused on quantity effects. Turning to earnings polarization, we define:

$$JP_i^{earn} = HIGH_i^{earn} + LOW_i^{earn} - MID_i^{earn},\ \forall i. \tag{6}$$

Here, $HIGH_i^{earn}$ is the earnings of worker i in high-wage occupations over the years 2000-2009, relative to i's annual earnings in 1999; LOW_i^{earn} and MID_i^{earn} are defined analogously. Employing the same instrumental-variables approach as before, the positive coefficient indicates that rising import competition from China has caused earnings polarization in Denmark (column 6). We also see that the coefficient in the earnings regression is somewhat higher than in the employment regressions (columns 5, 6). Wage growth for exposed workers in the sample has been relatively low for workers in the middle of the distribution, consistent with the overall wage growth pattern in Denmark of Figure 1.

3.3 Job polarization and shifts between sectors

Like other high-income countries, Denmark's economy has shifted from manufacturing to services in recent years. Nonetheless, as we have seen in Figure 2 manufacturing plays a role in generating the polarization pattern. In this section we ask whether job polarization due to import competition can be explained by the shift from mid-wage jobs abundant manufacturing towards services.

We decompose a worker's employment in each of the three wage categories into employment spells in broad sectors of the economy. Panel A of Table 5 shows instrumental variable results for mid-wage employment, distinguishing manufacturing from non-manufacturing employment, as well as isolating the services sector (columns 2, 3, and 4 respectively).

The import-competition induced decline of mid-wage employment is concentrated in manufacturing (column 2), whereas outside manufacturing exposed workers have actually higher mid-wage employment than not-exposed workers. Import competition reduces labor demand first and foremost for manufacturing workers, not generally for mid-wage workers.

Gains in high-wage employment are distributed more broadly across sectors (Panel B). A relatively large portion is in manufacturing (columns 2), and to the extent that there are high-wage gains outside manufacturing they are concentrated in services (columns 3, 4). The gains in manufacturing are in line with recent findings that import competition forces firms to downsize at the same time when they shift their demand towards higher skill-requiring activities (Utar 2014).

At the lower end of the wage distribution, import competition from China reduces low-wage employment in manufacturing (Panel C, column 2). Taking the manufacturing results in column 2 of Panels A, B, and C together highlights that analyses limited to manufacturing might underestimate the role of trade for labor market outcomes. While manufacturing is the sector with the bulk of mid-wage employment declines, high-wage gains in manufacturing are limited and manufacturing employment in low-wage occupations does not increase, instead it decreases. There is no trade-induced employment polarization within manufacturing. It is found only when we trace out worker movements through the entire economy.

The increase in low-wage employment is almost entirely due to transitions to the service sector (Panel C, columns 3 and 4). This confirms the descriptive transitions from machine operator to personal and protective service occupations above (Figure 5). Earlier work has shown that technical change has increased low-wage service employment in high-income countries (Autor and Dorn 2013); our findings demonstrate that import competition also accounts for part of the economy-wide shift in high-wage countries towards low-wage services jobs. This raises the question whether import competition and technical change have in fact distinct effects or whether import competition mimics the polarizing effects of technical change.

Table 5: Channels of Job Polarization Due to Trade

	(1)	(2)	(3)	(4)
Panel A.	Mid-Wage Employment 2000-2009			
	MID^e	MID^e Within Manuf.	MID^e Outside Manuf.	MID^e Service Sectors
Δ Imports from China	-5.273*	-6.946°	1.673	1.122
	(2.282)	(3.714)	(2.056)	(1.551)
N	900,329	900,329	900,329	900,329
First-stage F-test [p-value]	[0.000]	[0.000]	[0.000]	[0.000]
Panel B.	High-Wage Employment 2000-2009			
	$HIGH^e$	$HIGH^e$ Within Manuf.	$HIGH^e$ Outside Manuf.	$HIGH^e$ Service Sectors
Δ Imports from China	2.307*	1.758	0.550	1.220
	(1.075)	(1.977)	(1.857)	(1.756)
N	900,329	900,329	900,329	900,329
First-stage F-test [p-value]	[0.000]	[0.000]	[0.000]	[0.000]
Panel C.	Low-Wage Employment 2000-2009			
	LOW^e	LOW^e Within Manuf.	LOW^e Outside Manuf.	LOW^e Service Sectors
Δ Imports from China	2.369*	-2.031°	4.401**	4.347**
	(1.178)	(1.071)	(1.353)	(1.348)
N	900,329	900,329	900,329	900,329
First-stage F-test [p-value]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Estimation by two stage least squares. Robust standard errors clustered at the 3-digit industry level in parentheses. All specifications include demographic (gender, age, immigration status), education, hourly wage, labor market history (unemployment history, linear and square terms of experience), union and unemployment insurance memberships, firm (size, wage, separation rate), as well as product-level variables as described under Table 3. All specifications also include two digit occupation fixed effects and two-digit industry fixed effects. °, * and ** indicate significance at the 10 %, 5% and 1% levels respectively.

3.4 Technical change, offshoring and other explanations

Two approaches are adopted to distinguish the contribution of import competition to job polarization from other factors. First, we consider well-known measures of technical change and offshoring employed in the literature, and second, we perform a worker-task level analysis using task characteristics of occupations from the O*NET database (see section 4.2).

Turning to the first approach, the routine task intensity index captures an occupation's susceptibility to routine-biased technical change (Autor, Levy and Murnane 2003; RTI). We also examine the role of offshoring based on the offshorability of tasks, in particular whether they require personal interaction (Blinder and Krueger 2013).[23] Because both routine task intensity and offshoring vary at the two-digit occupation level we replace our two-digit occupation fixed effects with more aggregate occupation variables.[24] The Chinese import competition estimate of about 10 shows that our results are not much affected by this and the associated change in sample size (see column 1 in Table 6, and column 4 in Table 4).

Offshoring enters with a positive sign, indicating that workers in more offshorable occupations tend to be more prone to job polarization (column 2). Technical change as captured by the routine task intensity contributes to employment polarization as well (column 3). Importantly, the Chinese imports competition estimate does not change much upon inclusion of the offshoring and technical change variables. Our evidence on offshoring is in line with the results in Firpo, Fortin, and Lemieux (2011).

Which part of the occupation distribution is affected most strongly by technical change, offshoring, and import competition? The following separates employment in low-, mid-, and high-wage occupations (columns 4, 5, and 6). First, import competition from China contributes significantly to job polarization through changes in low-, mid-, and high-wage employment. In contrast, offshoring can explain increases in workers' low-wage employment but not in high-wage employment. Conversely, technical change increases high-wage employment but does not lead to a significant increase in low-wage employment. Thus, only the combination of routine-biased technical change and offshoring generates the full pattern of job polarization, in contrast to import competition which explains all three aspects of job polarization.

We report standardized beta coefficients to gauge economic magnitudes (Table 6, hard brackets). A one standard deviation change in import competition has roughly the same effect on

[23]This measure has been constructed by Blinder and Krueger using the Princeton Data Improvement Initiative dataset and employed in Goos, Manning and Salomons (2014). We have also experimented with an alternative measure of offshorability due to Goos, Manning, and Salomons (2014), finding that this does not affect our main findings. See Table B-5 in the Online Appendix.

[24]We employ indicator variables for working in a high-, mid-, and low-wage occupation in the year 1999, as well as a measure of each four-digit's occupation's propensity to interact with computers.

Table 6: Job Polarization, Offshoring, Technology, and Trade

	JP^e	JP^e	JP^e	LOW^e	MID^e	$HIGH^e$
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Imports from China	10.194**	10.421**	10.574**	2.216°	-5.326*	3.032*
	(3.914)	(3.914)	(4.081)	(1.302)	(2.462)	(1.275)
	[0.043]	[0.044]	[0.045]	[0.027]	[-0.042]	[0.024]
Offshoring		0.170**	0.101°	0.108**	-0.083*	-0.091**
		(0.061)	(0.057)	(0.016)	(0.035)	(0.022)
		[0.024]	[0.014]	[0.043]	[-0.022]	[-0.024]
Routine Task Intensity			0.345**	0.041	-0.154*	0.149**
			(0.109)	(0.039)	(0.062)	(0.044)
			[0.050]	[0.017]	[-0.041]	[0.041]
Number of Observations	809,791	809,791	809,791	809,791	809,791	809,791
First-stage F-test	11.818	11.870	11.882	11.882	11.882	11.882
First-stage F-test [p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Estimation by two stage least squares. Robust standard errors that are clustered at the 3-digit industry level are reported in parentheses. Beta coefficients are reported in square brackets. All specifications include demographic (gender, age, immigration status), education, wage, labor market history (unemployment history, linear and square terms of experience), union and unemployment insurance memberships, firm variables (size, wage, separation rate), as well as product-level control variables as described under Table 3. All specifications also include two-digit industry fixed effects. In all regressions, initial occupations are controlled for by occupation indicators as high-, mid-, and low-wage occupations and the occupations' likelihood of interacting with computers (from O*NET). "Offshoring" is the offshorability of worker i's two digit occupation class, due to Blinder and Krueger (2013). "Routine Task Intensity" follows Autor, Levy and Murnane (2003) and Autor and Dorn (2013) and captures the routine task intensity of worker i's two digit occupation code. The sources of the offshoring and routine task intensity variables is Goos, Manning and Salomons (2014). The number of observations drops because there are no routine task intensity or offshoring measures for some of the Danish occupation codes. °, * and ** indicate significance at the 10 %, 5% and 1% levels respectively.

job polarization as a one standard deviation change in technical change, and both trade and technical change are more important than offshoring (column 3). How much of the observed decrease in mid-wage employment is accounted for by import competition? Comparing a worker at the 90th and the 10th percentile of exposure, import competition accounts for about 17% of the aggregate mid-wage employment decline (based on column 5). In contrast, the analogous 90/10 difference in routine task intensity accounts for about twice as much. Technical change has a larger effect because it operates throughout the economy, in contrast to import competition, which is concentrated in manufacturing. If instead of the 90/10 exposure difference in the economy we utilize the 90/10 difference for manufacturing workers, import competition explains a larger portion of the observed mid-level employment decline than technical change, namely 36%, versus 30%.

4 Evidence from a quasi-natural experiment

4.1 Job polarization for Denmark's textile workers

We now examine polarization in the quasi-experimental setting of the removal of quantitative restrictions on China's textile exports. Our analysis encompasses all 1999 textile workers who are of working age throughout the years 2002 to 2009. These years, following China's entry into the WTO in December 2001, are times of high rates of textile import growth from China.

The Chinese import competition variable now is defined as the share of revenue of worker i's firm in 1999 derived from domestically produced goods that will later be affected by the quota removal. In the regression with cumulative mid-wage employment as dependent variable, the coefficient is about -1.5, implying that highly exposed textile workers have typically about half a year less mid-wage employment than little-exposed workers (Table 7, column 2). The results show that Chinese import competition also raises high- and low-wage employment (Panel A, columns 1 and 3); the implied difference between highly exposed and little-exposed workers is about three months of employment each. The combined polarization effect of import competition exposure, or the time that workers spend away from mid- toward high- or low-wage jobs due to import competition, is about a year of employment (Panel A, column 4). As before, the decline in mid-wage employment due to import competition is similar to the employment increases in high- and low-wage jobs taken together (Panel A, columns 1, 2, and 3). Employing the hours measure, JP^{hrs}, we find similar albeit somewhat stronger effects, indicating that the November-based employment measure does not over-estimate the extent of job polarization. Polarization measured in terms of earnings is stronger than in terms of employment (column 6). Wage changes reinforce the polarization pattern.

The previous specifications include fixed effects for each two-digit occupation. In Panel B we instead include indicators for the worker's four-digit occupation class. This means that we add about two hundred fifty fixed effects for narrowly defined occupations within the textiles industry. The advantage of this is that it arguably eliminates any remaining differences across occupations in terms of their propensity to be affected by technical change or offshoring. It turns out that the results are quite similar and the effect of import competition on job polarization is very robust (compare Panels A and B). Overall, the economy-wide analysis and the quasi-natural experiment lead to similar results. This provides additional support for our findings.

Table 7: Job Polarization and Import Competition: Quasi-Experimental Evidence

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A.	$HIGH^e$	MID^e	LOW^e	JP^e	JP^{hrs}	JP^{earn}
Import Competition	0.692**	-1.513**	0.746**	2.952**	3.617**	4.909**
	(0.252)	(0.344)	(0.205)	(0.512)	(0.645)	(0.768)
N	10,487	10,487	10,487	10,487	10,360	10,487
Panel B.	$HIGH^e$	MID^e	LOW^e	JP^e	JP^{hrs}	JP^{earn}
Import Competition	0.570*	-1.387**	0.796**	2.753**	3.432**	4.735**
	(0.239)	(0.373)	(0.201)	(0.541)	(0.657)	(0.777)
Four-digit occupation FEs	yes	yes	yes	yes	yes	yes
N	10,487	10,487	10,487	10,487	10,360	10,487

Notes: Estimation by OLS. Robust standard errors clustered at the firm-level are reported in parentheses. Cumulative worker-level dependent variables are defined over 2002-2009. "Import Competition" is a continuous trade exposure variable which is defined as the manufacturing revenue share of 8-digit Combined Nomenclature goods that were subject to removal of quotas for China in 1999 of worker i's employer. All specifications include demographic (gender, age, immigration status), education, hourly wage, labor market history (unemployment history, linear and square terms of experience), union and unemployment insurance memberships, and firm variables (size, wage, separation rate). In addition, all specifications include two-digit occupation fixed effects in Panel A and four-digit occupation fixed effects in Panel B. °, * and ** indicate significance at the 10 %, 5% and 1% levels respectively.

In Table 8 we examine trade side-by-side with offshoring and technical change for workers who were in 1999 employed in the textile industry. Our measures of offshoring and technical change are the same as before.[25] Offshoring contributes to job polarization (column 2), and technical change enters significantly as well (column 3). Notice that the coefficient on import competition changes little with the inclusion of these variables.

Based on the standardized beta coefficients in hard brackets, import competition in textiles has been an important cause of job polarization, more so than technical change or offshoring (column 3). This is plausible given that textile workers were among those most strongly affected by imports from China. In particular, based on the coefficient in Table 7, column 2, we calculate that import competition accounts for about 25% of the total decline in mid-wage

[25] Column 1 shows a similar coefficient for Chinese import competition in the somewhat smaller sample for which we have information on worker offshorability and routine task intensity (RTI) (compare column 1, Table 8 with column 4, Table 7).

employment, compared to 17% in the economy at large.[26]

Table 8: Alternative Explanations to Import Competition: Quasi-Experimental Evidence

	JP^e	JP^e	JP^e
	(1)	(2)	(3)
Import Competition	3.075**	3.033**	2.999**
	(0.516)	(0.514)	(0.517)
	[0.088]	[0.087]	[0.086]
Offshoring		0.160°	0.145
		(0.087)	(0.088)
		[0.041]	[0.037]
Routine Task Intensity			0.312*
			(0.155)
			[0.055]

Notes: N=9,127 in all columns. Estimation by two stage least squares. Robust standard errors clustered at the firm-level are reported in parentheses. Cumulative worker-level dependent variables are defined over 2002-2009. "Import Competition" is a continuous trade exposure variable which is defined as the manufacturing revenue share of 8-digit Combined Nomenclature goods that were subject to removal of quotas for China in 1999 of worker i's employer. All regressions include demographic (gender, age, immigration status), education, hourly wage, labor market history (unemployment history, linear and square terms of experience), union and unemployment insurance memberships, and firm variables (size, wage, separation rate). In all specifications workers' initial occupations are controlled for using high-, mid-, and low-wage occupation indicators and occupation's propensity to interact with computers (varies at the four-digit occupation). °, * and ** indicate significance at the 10 %, 5% and 1% levels respectively.

We now address why import competition and technical change have distinct effects on job polarization.

4.2 Import competition versus technical change: task-level evidence

This section employs information on tasks from the U.S. Department of Labor's O*NET database at the level of individual workers in Denmark to distinguish the effect of trade

[26] We have also examined the question of within-versus-between sector employment effects in the case of this quasi-natural experiment, finding strong evidence that employment increases in the high- and low-wage occupations are primarily in the service sector (see Table B-6 in the Online Appendix).

from that of technology.[27] We interact the importance of a particular task in the worker's occupation with the degree to which this worker is exposed to rising import competition from China. Our specification is the same as in Table 7, Panel A except that instead of two-digit occupational fixed effects we include a measure of the importance of a particular task in the worker's four-digit occupation together with the interaction of this variable with import exposure. All regressions include the full set of worker and firm variables from above.[28]

We span the task space by focusing on two dimensions, namely whether a task is routine or non-routine (routine-ness dimension) and whether a task is manual or cognitive (manual dimension). We employ O*NET questions to map occupations with these tasks as employed in the literature (Autor, Levy, Murnane 2003, Autor 2013, Firpo, Fortin, Lemieux 2011). Panel A of Table 9 summarizes the results for four tasks: "Spend time making repetitive motions", "Pace Determined by Speed of Equipment", "Manual Dexterity", and "Finger Dexterity". These tasks are examples of routine manual tasks. Tasks in Panel B are non-routine manual tasks, followed by routine cognitive tasks (Panel C), while non-routine cognitive tasks are listed last (Panel D).

For each of the task indicators, Table 9 notes results for two different specifications, one in which the dependent variable is mid-wage employment over 2002-2009 (MID^e), and the other is $HIGH^e + LOW^e - MID^e$. Of key interest is the trade exposure-task content interaction variable, whose sign and significance is shown in Table 9. Complete results for these specifications are reported in the Online Appendix.

To begin with, the negative sign for the O*NET indicator "Spend time making repetitive motions" in the MID^e regression indicates that exposed workers employed in occupations in which repetitive motions are important experience larger declines in mid-wage employment than the average exposed worker. The positive sign in the second column says that workers in these occupations also have a higher likelihood of an increase in high- and low-wage employment due to import competition. The finding that workers performing routine manual tasks are susceptible to trade-induced job polarization is robust to considering other routine manual tasks (rows 2 to 4 in Panel A). Strikingly, we find the same coefficient pattern for non-routine manual tasks, such as "Gross Body Coordination" (Panel B). This is an important finding because it shows that trade-induced job polarization occurs in occupations in which workers perform manual tasks, whether these are routine or non-routine tasks.

[27] O*NET stands for Occupational Information Network. See the Online Appendix for details.

[28] We also include indicators for working in high-, mid-, or low-wage occupations in 1999.

We now consider cognitive tasks with a high routine component (Panel C). An example of this is “Evaluating Information to Determine Compliance with Standards”. It requires cognitive abilities to judge compliance with standards, however it is a task performed in a particular way and hence subject to some routine. For workers engaged in these tasks, import competition reduces mid-wage employment by significantly less than for other observationally similar exposed worker. These workers also see relatively low increases in high- and low-wage employment, to the point that these workers do not much contribute to trade-induced job polarization (see Table B-9 in the Online Appendix). We find the same pattern with an alternative routine cognitive tasks measure, the importance of repeating the same task (Panel C, second row).

Table 9: Signs of interaction between import competition and task variable

Dep. Var.	MID^e	JP^e
A. Trade and Routine Manual Tasks		
Spend time making repetitive motions	**-**	**+**
Pace Determined by Speed of Equipment	**-**	**+**
Manual Dexterity	**-**	**+**
Finger Dexterity	**-**	**+**
B. Trade and Non-Routine Manual Tasks		
Multilimb Coordination	**-**	**+**
Gross Body Coordination	**-**	**+**
Response orientation	**-**	**+**
C. Trade and Routine Cognitive Tasks		
Evaluating Information to Determine Compliance with Standards	**+**	**-**
Importance of Repeating Same Tasks	**+**	**-**
D. Trade and Non-Routine Cognitive Tasks		
Mathematical Reasoning	**+**	**-**
Inductive Reasoning	**+**	**-**
Developing Objectives and Strategies	+	**-**
Making Decisions and Solving Problems	+	-

Notes: Bold indicates significance at the standard levels based on robust standard errors that are clustered at the firm-level. Full results are provided in the Online Appendix.

Finally, we show results for workers performing intensively non-routine cognitive tasks, such as those involving mathematical reasoning (Panel D). Exposed workers that perform such tasks experience lower mid-wage employment declines than the typical exposed worker. These workers are also less likely than the typical exposed worker to experience an increase in low-wage employment (in fact, they do not gain low-wage employment at all: see the Online Appendix), and overall, exposed workers performing abstract cognitive tasks hardly contribute to job polarization. Panels C and D show that workers performing cognitive tasks experience less trade-induced polarization, a result that is independent of whether the task is routine or not.

Thus while technical change's impact on job polarization depends on the routine-ness of a task, the effect of import competition hinges on whether a task is cognitive or manual in nature. In many countries computerized machines and robots have increasingly taken over the performance of routine tasks. The fact that to date machines do not perform certain non-routine tasks that well determines the extent to which domestic manufactures are still produced by workers. Import competition, however, pits workers in Denmark against workers in China. From this perspective it is not surprising that technical change and import competition complement each other in explaining job polarization.

5 Normative implications of trade-induced job polarization

While the previous analysis has focused on trade's role in generating the U-shaped pattern of job polarization, in this section we turn to a number of related normative issues. First, we distinguish workers' upward from downward movements, which have different welfare effects. The impact of trade on hourly wages is also discussed. Second, this section quantifies the contribution of import competition to recent changes in inequality. Third, we speak to the educational policy debate by examining the performance of workers with different forms of education. The analysis is based on the economy-wide sample of Section 3 and the same instrumental variables approach employed before.

5.1 Upward versus downward movements and wages

We begin with the effect of rising import competition on employment and wages (Table 10, Panels A and B, respectively). The analysis focuses on the n = 458,605 workers that were employed in mid-wage occupations in the year 1999. Among these, those workers with high-wage employment during the years 2000-2009 can be thought of moving up whereas those with low-wage employment are the downward movers. Columns 1 and 3, respectively, show the effect of rising import competition on these employment transitions.

Table 10: Transitions from Mid-Wage Occupations Due to Competition with China

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A.				**Panel B.**		
Dep. Var.	$HIGH^e$	MID^e	LOW^e	$WAGE^{Hi}$	$WAGE^{Mid}$	$WAGE^{Low}$
ΔIP^{CH}	2.202*	-4.259	0.875	-0.006	-0.303	-0.350*
	(1.082)	(2.840)	(0.934)	(0.231)	(0.220)	(0.150)
N	458,605	458,605	458,605	112,514	407,188	107,888
	All Mid-Wage Workers	Operators	Craft workers	All Mid-Wage Workers	Operators	Craft Workers
Panel C.				**Panel D.**		
Dep. Var.	$HIGH^e$ as Associate Professional			LOW^e as Service Worker		
ΔIP^{CH}	1.746*	0.500	1.813	0.976°	0.851°	0.515°
	(0.876)	(0.393)	(1.265)	(0.520)	(0.471)	(0.278)
N	458,605	133,914	196,409	458,605	133,914	196,409

Notes: Estimation by two stage least squares. Robust standard errors clustered at the 3-digit industry level are reported in parentheses. All specifications include demographic (gender, age, immigration status), education, labor market history (unemployment history, linear and square terms of experience), union and unemployment insurance memberships, firm variables (size, wage, separation rate), as well as product-level control variables as described in Table 3 notes. All specifications also include two-digit industry fixed effects. Regressions in columns (1)-(3) also include base year (1999) hourly wage. °, * and ** indicate significance at the 10 %, 5% and 1% levels respectively.

First, how many 1999 mid-wage workers are there that have high- and low-wage employment in the next decade? Panel B on the right shows there are 112,514 and 107,888 of these workers, respectively, or, around 25% each of the 1999 mid-wage workers move up or down during the sample period. Close to 90% of workers have mid-wage employment during the years 2000-2009, or alternatively, more than 10% of the 1999 mid-wage workers transition immediately out of mid-wage jobs.

Import competition causes significant upward employment movements, see column 1. The trade coefficient is smaller (and not significant) for downward movements (column 3), though the positive point estimate is consistent with polarization. In Panel B on the right we see that of the 1999 mid-wage workers that move into low-wage employment, those exposed to import competition have lower hourly wages than non-exposed workers (column 6). The coefficient of -0.35 translates into an hourly wage of 4 Kroner, or 2 percent, less. In contrast, exposed and non-exposed mid-wage workers moving into high-wage employment have virtually the same hourly wages (column 4).

Thus, import competition has a more powerful upward employment effect than on downward employment transitions. On net this can be seen as a positive effect. This quantity effect is to some extent offset by the wage outcomes, because workers that are moving from mid- into low-wage jobs due to import competition make relatively low hourly wages. These results are confirmed when the definition of upward movements is extended to include transitions from 1999 low-wage workers to high-wage employment, and analogously, downward movements include 1999 high-wage workers moving into low-wage employment. The upward quantity impact of trade exposure is relatively strong, while at the same time wages of exposed workers in low-wage occupations are relatively low as well (not shown).

Trade-induced upward movements for particular subsets of occupations are presented in the lower part of Table 10. The first is transitions from any mid-wage occupations to associate professionals, a high-wage occupation (ISCO class 3; column 1). Next we present the impact of import competition with China on the transition of plant and machine operators (ISCO 8) and crafts workers (ISCO 7) to associate professionals (column 2 and 3). Among the mid-wage workers, there are about 134,000 operators and 196,000 crafts workers. Trade exposure significantly increases transitions into associate professional occupations for all mid-wage workers (column 1). Comparing operators with crafts workers, though the instrumental-variables estimates are not significant, we see that the relatively high point estimate is evidence that craft workers are more likely to move upward into associate professional occupations than operators (columns 2 and 3).

For trade-induced downward transitions we focus on the low-wage occupation of service and shop workers (ISCO 5; see Panel D). The coefficient of just below one in column 4 means that import exposure increases employment in these occupations by about 0.6 months on average for the set of all 1999 mid-wage workers. This is quite close to the impact of trade on operators, whereas craft workers transition to low-wage service occupations to a lesser extent than the average worker in mid-wage occupation in 1999 (columns 5 and 6). In sum, the typical craft worker can expect to do better in terms of trade-induced job polarization than the typical operator: craft workers are both more likely to move up and less likely to move down compared to machine operators. Overall, this analysis has shown that the result of job polarization due to rising import competition holds up quite well even for transitions between some of the most important individual occupations.

5.2 Import competition and inequality

While incomes in Denmark are traditionally distributed relatively equally, in recent years inequality in Denmark has risen (Bjørnskov, Neamtu, and Westergård-Nielsen 2012). We are interested in the implications of our analysis for inequality in Denmark as captured by earnings of workers in different parts of the wage distribution. A simple measure of inequality is the earnings share of workers in the tails, that is, the share of low-wage plus high-wage earnings. More weight in the tails means higher inequality.

Employing the average 1999 wages paid in high-, mid-, and low-wage positions in Denmark, the sum of high- and low-wage employment accounts for 48% of total sample earnings in the year 1999. In contrast, the share of high- plus low-wage earnings has risen to 59.5% by the year 2009, an increase in earnings inequality of 11.5 percentage points. Based on the employment changes caused by rising import competition estimated in Table 4 and the 90/10 exposure difference, trade accounts for about 16% of the increase in earnings inequality. Adjusting wages as they actually changed between 1999 and 2009 instead of holding wages constant at the 1999 level increases the contribution of trade only slightly. We conclude that rising import competition accounts for about 16% of the rise in inequality in Denmark, with most of the effect due to quantity, not price (wage) changes.

5.3 Job polarization and education

This section considers education as a determinant of trade-induced job polarization. In the first part we examine the impact of trade exposure on workers employment trajectories depending on three levels of education (high school, vocational education, and college education). Second, we contrast the performance of workers who have different forms of vocational education.

We begin by including two additional interaction variables between exposure to trade and education, ΔIP^{CH}*College and ΔIP^{CH}*HighSchool. As a consequence, the linear Chinese import competition variable captures the impact of trade exposure on vocationally trained workers (vocational training is the omitted category). Employment results are shown on the left and wage results on the right side of Table 11.[29]

[29] All specifications include indicator variables for the three education levels, two-digit industry and occupation fixed effects, as well as the other covariates of our baseline specification (Table 3, column 5).

Table 11: Education and Job Polarization

	(1) $HIGH^e$	(2) MID^e	(3) LOW^e	(4) $WAGE^{Hi}$	(5) $WAGE^{Mid}$	(6) $WAGE^{Low}$
ΔIP^{CH}	2.816*	-4.380*	1.237	0.064	-0.268	-0.617**
	(1.218)	(2.228)	(1.275)	(0.307)	(0.204)	(0.237)
ΔIP^{CH}*HighSchool	-2.909*	-0.578	1.744°	-0.253*	$-0.168°$	0.212°
	(1.332)	(1.451)	(1.031)	(0.109)	(0.093)	(0.118)
ΔIP^{CH}*College	4.526*	-4.053	2.450°	0.462	0.472*	0.347°
	(2.292)	(3.267)	(1.334)	(0.360)	(0.207)	(0.186)
N	900,329	900,329	900,329	388,589	559,447	271,551

Notes: Estimation by two stage least squares. Robust standard errors clustered at the 3-digit industry level are reported in parentheses. All specifications include demographic (gender, age, immigration status), education, labor market history (unemployment history, linear and square terms of experience), union and unemployment insurance memberships, firm variables (size, wage, separation rate), as well as product-level control variables as described in Table 3 notes. All specifications also include two-digit occupation and industry fixed effects. Regressions in columns (1)-(3) also include base year (1999) hourly wage. °, * and ** indicate significance at the 10 %, 5% and 1% levels respectively.

The first result is that the chance of a trade-exposed worker to be in a high-paying occupation is strictly increasing in the worker's level of education (Table 11, column 1). Vocationally-trained workers have more high-wage employment than comparable non-exposed workers, college-educated workers have even more high-wage employment, while high-school educated workers experience no high-wage employment increase through trade. Furthermore, there is evidence that vocationally-trained workers exposed to trade lose mid-wage and increase low-wage employment (columns 2 and 3, respectively), and, overall, workers with vocational training are not atypical contributors to the trade-induced polarization pattern.

Turning to the wage results on the right, we see that in contrast to the chance for high-wage employment, more education does not necessarily benefit trade-exposed workers in terms of their hourly wages. In particular, trade-exposed low-wage workers with any education level earn lower wages than non-exposed workers, and the extent of this hourly wage discount is highest for vocationally-trained workers (column 6). One reason for the relatively low wages of vocationally-trained workers in low-wage occupations may be that vocational training tends to be more specific to particular occupations than either college or high school education, and the specificity might be a disadvantage when the task profile of the economy undergoes rapid changes.

In general, vocationally trained, mid-skill, workers contribute to job polarization as we have seen above (Table 11, first row, columns 1 to 3). Since it might be important to separate workers holding different forms of vocational education, in the following we narrow the focus to workers who are trained for manufacturing vocations, such as welders, toolmakers, or industrial cabinet makers, versus workers trained for service vocations, such as orthopedic technicians, office workers, or decorators. Within the group of workers trained for service vocations we present separate results for the set of workers trained for information-technology (IT) related vocations, e.g. IT assistants.[30]

In Table 12 we present results where we interact our exposure to import competition variable with an indicator variable for particular forms of vocational training that worker i has completed: specific to the manufacturing sector (MVoc), service sector (SVoc), and information technology (ITVoc) vocations, respectively in Panels A, B, and C.[31] The impact of trade exposure on mid-wage employment of vocationally trained workers with manufacturing focus is equal to about -2.1, which is the sum of the two coefficients shown in Table 12 (Panel A, column 2). This translates into a smaller mid-wage employment reduction than either the average vocationally trained worker (-4.4, Table 11, column 2) or the typical worker that is not vocationally trained with a manufacturing focus (-6.0, Table 12, column 2). Thus, a formal education on manufacturing vocations shields a worker to some extent from mid-wage employment reductions as these workers are highly skilled for manufacturing.

[30] This classification has been obtained by coding around 3,000 of the education titles available in Denmark; see the Online Appendix section 1.2 for details.

[31] All specifications include indicator variables for each of these education levels.

Table 12: Vocational Education and Job Polarization

	(1) $HIGH^e$	(2) MID^e	(3) LOW^e
Panel A: Manufacturing			
Δ Imports from China	2.432*	-5.979*	2.504*
	(1.105)	(2.336)	(1.220)
Δ Imports from China*MVoc	-0.695	3.859*	-0.564
	(1.428)	(1.680)	(0.628)
N	900,329	900,329	900,329
Panel B: Services			
Δ Imports from China	1.883°	-5.125*	2.870*
	(1.092)	(2.261)	(1.196)
Δ Imports from China*SVoc	2.114*	-0.998	−2.297°
	(0.986)	(1.231)	(1.252)
N	900,329	900,329	900,329
Panel C: Information Technology			
Δ Imports from China	2.278*	-5.311*	2.421*
	(1.072)	(2.261)	(1.173)
Δ Imports from China*ITVoc	8.041°	-3.685	-2.890*
	(4.309)	(3.679)	(1.369)
N	900,329	900,329	900,329

Notes: Estimation by two stage least squares. Robust standard errors clustered at the 3-digit industry level are reported in parentheses. All specifications include demographic (gender, age, immigration status), education, hourly wage, labor market history (unemployment history, linear and square terms of experience), union and unemployment insurance memberships, firm variables (size, wage, separation rate), as well as product-level control variables as described in Table 3 notes. All specifications also include two-digit occupation and industry fixed effects. Education control variables also include manufacturing, service and IT specific vocational education indicators. °, * and ** indicate significance at the 10 %, 5% and 1% levels respectively.

Next, it is clear that vocationally trained workers with a service focus are central to the result that exposed vocationally trained workers see no increase in low-wage employment (Panel B, column 3). The trade-induced increase in personal and protective service jobs shown above is therefore likely not coming from workers with service-oriented vocational training. Furthermore, service-orientation roughly doubles trade-induced high-wage employment relative to other forms of education (column 1). On the downside, vocational training with a service focus is not effective in cutting down the decline in mid-wage employment of exposed workers (Panel B, column 2). Finally, vocationally trained workers who are educated in information technology (IT) have almost four times more high-wage employment than the typical worker with other education (Panel C, column 1). While we know that college education matters for high-wage employment gains (Table 11, column 1), comparing column 1 of Panel A with Panel C also indicates that mid-skilled workers trained for information technology (IT) vocations have more than five times more high-wage employment than other observationally similar mid-skilled workers with manufacturing focus.[32] Furthermore, there is no evidence that workers with IT education who are exposed to import competition move into low-wage jobs (column 3).

The picture that emerges from these results is that a while manufacturing focus in vocational training raises the chance that workers experience smaller mid-wage employment declines, it does not prevent workers from shifting into low-wage employment. In contrast, service orientation in vocational training by and large eliminates the chance that exposed workers shift into low-wage jobs, and strongly increases the chance that a worker moves into high-wage occupations. Outcomes are highly heterogeneous for workers with different forms of vocational education. Overall, whatever temporary protection manufacturing orientation gives in mid-wage occupations has to be compared with the relatively high long-run earnings potential that appears to come only with certain service-oriented vocational training or college education.

6 Conclusions

Employing matched worker-firm data for much of Denmark's economy during the early 2000s we have shown that competition with China can explain job polarization in high-income countries. Individual transitions between sectors, observed through worker-level data, are crucial for the U-shaped employment changes of job polarization. Overwhelmingly rising import competition impacts manufacturing workers earning mid-level wages. Outcomes are heterogeneous, with some workers moving up and others down in the wage distribution. Low-wage employment increases are mainly in services, in contrast to trade–induced gains in high-wage employment, which are split between manufacturing and the service sector. The up- versus down movement hinges primarily on workers' education. Short of college education—which takes relatively long and is arguably not for everyone—, vocational training has promise if it is targeted to certain service occupations, especially those involving

[32] We arrive at the same conclusion when we conduct the analysis only among vocationally trained workers, see Table B-11 in the Online Appendix.

technical and computer skills.

Our first conclusion follows directly from finding that import competition is a quantitatively important cause of job polarization. Consequently, the debate about job polarization as a phenomenon, and what it implies for government policy, can from now on consider not only technical change but also rising import competition. In particular, policy initiatives towards trade reform need to consider the strong possibility that in high-income countries, job polarization is a likely outcome. Conversely, some of the concerns about the impact of information & communication technologies (ICTs) on worker outcomes can be put to rest because the outcomes are actually due to import competition, not technical change.

A critic might question that any of this matters. Aren't trade, offshoring, and technical change all just different facets of globalization that are inextricably linked? There is no doubt that offshoring is related to ICT innovations, or that not only abundant unskilled labor but also industrial robots (and hence ICT) have contributed to the rising export capacity in emerging countries.[33] However this does not mean that one should give up analyzing the unique drivers of each of the job polarization causes. In our worker-task analysis we have shown that the influence of technical change and import competition can be clearly delineated. We expect that future research can go much further along these lines.

Second, rising import competition does not only have the well-documented negative effects on employment and (nominal) earnings of workers in high-income countries. Import competition moves some workers into high-wage jobs, accounting for about 8% of the total increase in high-wage employment in Denmark during the early 2000s. For these workers, import competition provides the incentive to switch to a high-wage career path. Import competition, in the words of Schumpeter, is a force of creative destruction. This important point has not been emphasized in the recent trade and labor literature. It does not mean that this shift for some workers to high-wage jobs is costless in the short run. However, we can now start to think about how to make medium-term transitions to high-earning career paths more likely. The debate about globalization gains in high-wage countries does not have to start and end largely with the observation that globalization makes many goods cheaper in high-income countries.

Our treatment of technical change and offshoring differs somewhat from the way we approach the role of import competition. In particular, it is one thing to show that jobs with a high

[33] China is the largest buyer of industrial robots in the world since 2014, Financial Times (2014).

degree of offshorability contribute to job polarization, but it is another to show that offshoring actually causes job polarization. Similarly, one might prefer an analysis of technical change in terms of computers instead of the task characteristics of workers that are replaced by computers. Given our emphasis on the role of import competition we adopt a conservative approach and treat any association with offshoring and technical change as these factors causing job polarization. While this arguably does not stack the analysis in favor of finding a major role for import competition, it would be useful for future work to employ direct measures and comparable identification strategies for all suspected causes of job polarization and other labor market outcomes of globalization.

References

[1] **Autor, David** 2010. "The Polarization of Job Opportunities in the U.S. Labor Market: Implications for Employment and Earnings", Center for American Progress and The Hamilton Project.

[2] **Autor, David** 2013. "The "task approach" to labor markets: an overview", *Journal for Labour Market Research*, 46(3): 185-199.

[3] **Autor, David, and David Dorn** 2013. "The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market", *American Economic Review*, 103(5): 1553-1597.

[4] **Autor, David, David Dorn, and Gordon Hanson.** 2013. "The China Syndrome: Local Labor Market Effects of Import Competition in the United States", *American Economic Review*, 103(6): 2121-2168.

[5] **Autor, David, David Dorn, and Gordon Hanson.** 2015. "Untangling Trade and Technology: Evidence from local Labor Markets", *Economic Journal*, 125(584): 621-646.

[6] **Autor, David, David Dorn, Gordon Hanson and Jae Song.** 2014. "Trade Adjustment: Worker Level Evidence", *The Quarterly Journal of Economics*, 129: 1799-1860.

[7] **Autor, David, Lawrance F. Katz, and Melissa S. Kearney** 2006. "The Polarization of the U.S. Labor Market", *American Economic Review: Papers and Proceedings*, 96(2), 189-193.

[8] **Autor, David, Lawrance F. Katz, and Melissa S. Kearney** 2008. "Trends in U.S. Wage Inequality: Revising the Revisionists", *The Review of Economics and Statistics*, 90(2), 300-323.

[9] **Autor, David, Levy, Frank, and Richard Murnane** 2003. "The Skill-Content of Recent Technological Change: An Empirical Investigation", *Quarterly Journal of Economics*, 118, 1279-1333.

[10] **Bagger, Jesper, Bent Jesper Christensen, and Dale T. Mortensen** 2014. "Wage and labor productivity dispersion: The roles of total factor productivity, labor quality, capital intensity, and rent sharing.", Working paper.

[11] **Becker, Sascha O. and Marc-Andreas Muendler** 2015. "Trade and tasks: an exploration over three decades in Germany", *Economic Policy*, 30(84): 589-641.

[12] **Bernard, Andrew B., Bradford J. Jensen and Peter K. Schott** 2006. "Survival of the best fit: Exposure to low-wage countries and the (uneven) growth of U.S. manufacturing plants", *Journal of International Economics*, Elsevier, vol. 68(1), 219-237.

[13] **Bjørnskov, Christian, Ioana Neamtu, and Niels Westergård-Nielsen** 2012. "Growing Inequality And Its Impacts In Denmark", GINI Country Report for Denmark.

[14] **Blinder, Alan, and Alan Krueger** 2013. "Alternative Measures of Offshorability: A Survey Approach", *Journal of Labor Economics*, 31(2): S97-S128

[15] **Bloom, Nicholas, Mirko Draca, and John Van Reenen** 2016. "Trade induced technical change? The impact of Chinese imports on innovation and information technology", *Review of Economic Studies*, 83: 87-117

[16] **Brambilla, Irene, Amit Khandelwal and Peter Schott** 2010. "China's Experience Under the Multifiber Arrangement (MFA) and the Agreement on Textile and Clothing (ATC)", Robert Feenstra and Shang-Jin Wei (Eds), China's Growing Role in World Trade, NBER, Cambridge: MA.

[17] **Brandt, Loren, Chang-Tai Hsieh, and Xiaodong Zhu** 2008. "Growth and Structural Transformation in China." In *China's Great Economic Transformation*, edited by Loren Brandt and Thomas G. Rawski, 683-728. Cambridge University Press.

[18] **Bunzel, Henning** 2008. "The LMDG Data Sets", mimeo, Univeristy of Aarhus.

[19] **Dix-Carneiro, Rafael** 2014. "Trade Liberalization and Labor Market Dynamics", *Econometrica*, 82(3): 825-885.

[20] **Dix-Carneiro, Rafael, and Brian Kovak** 2015. "Trade Reform and Regional Dynamics: Evidence From 25 Years of Brazilian Matched Employer-Employee Data", unpublished manuscript.

[21] **Dustmann, Christian, Johannes Ludsteck, and Uta Schonberg** 2009. "Revisiting the German Wage Structure", *The Quarterly Journal of Economics*, 124, 843-881.

[22] **Ebenstein, Avraham, Ann Harrison, Margaret McMillan and Shannon Phillips** 2014. "Estimating the Impact of Trade and Offshoring on American Workers using the Current Population Surveys", *The Review of Economics and Statistics*, 96(3): 581-595.

[23] **Eriksson, Tor and Niels Westergaard-Nielsen** 2009. "Wage and Labor Mobility in Denmark, 1980-2000", appeared in *The Structure of Wages: An International Comparison*, (Eds.) Edward P. Lazear and Kathryn L. Shaw, Chicago: University of Chicago Press and National Bureau of Economic Research.

[24] **Financial Times** 2014. "China becomes largest buyer of industrial robots", June 1 2014. http://www.ft.com/intl/cms/s/0/a5cca8c0-e70c-11e3-aa93-00144feabdc0.html

[25] **Firpo, Sergio, Nicole Fortin, and Thomas Lemieux** 2011. "Occupational Tasks and Changes in the Wage Structure", IZA Discussion Paper 5542, Institute for the Study of Labor (IZA).

[26] **Foged, Mette and Giovanni Peri** 2016. "Immigrants' Effect on Native Workers: New Analysis on Longitudinal Data", *American Economic Journal: Applied Economics*, 8(2): 1-34.

[27] **Goldberg, Pinelopi and Nina Pavcnik** 2007. "Distributional Effects of Globalization in Developing Countries, *Journal of Economic Literature*, 45(1), pp. 39-82.

[28] **Goos, Maarten, and Alan Manning** 2007. "Lousy and Lovely Jobs: The Rising Polarization of Work in Britain", *The Review of Economics and Statistics*, 89(1), 118-133.

[29] **Goos, Maarten, Alan Manning, and Anna Salomons** 2009. "Job Polarization in Europe", *American Economic Review: Papers and Proceedings*, 99(2), 58-63.

[30] **Goos, Maarten, Alan Manning, and Anna Salomons** 2014. "Explaining Job Polarization: Routine-Biased Technological Change and Offshoring", *American Economic Review*, 104(8), 2509-2526.

[31] **Graetz, Georg and Guy Michaels** 2015 "Robots at Work", Center for Economic Performance Discussion Paper No. 1335.

[32] **Groes, Fane, Philipp Kircher, and Iorii Manovskii** 2015. "The U-Shapes of Occupational Mobility", *Review of Economic Studies*, 82(2): 659-692.

[33] **Hakobyan, Shushanik and John McLaren** 2016. "Looking for Local Labor-Market Effects of NAFTA", *The Review of Economics and Statistics*, *forthcoming.*

[34] **Harrigan, James, Ariell Reshef, and Farid Toubal** 2015. "The March of the Techies: Technology, Trade, and Job Polarization in France, 1994-2007", presented at NBER ITI Winter Meeting 2015.

[35] **Harrison Ann, John McLaren, Margaret McMillan** 2011. "Recent Perspectives on Trade and Inequality", *Annual Review of Economics*, Vol 3, pp 261-289.

[36] **Haskel, Jonathan E., Sonia C. Pereira, and Matthew J. Slaughter** 2007. "Does Inward Foreign Direct Investment Boost The Productivity Of Domestic Firms?", *The Review of Economics and Statistics*, August 2007, 89(3): 482-496.

[37] **Holzer, Harry** 2015. "Job Market Polarization and U.S. Worker Skills: A Tale of Two Middles", *Economic Studies*, The Brookings Institution.

[38] **Hummels, David, Rasmus Jorgensen, Jacob Munch, and Chong Xiang** 2014. "The Wage Effects of Offshoring: Evidence From Danish Matched Worker-Firm Data", *American Economic Review*, 104(6): 1597-1629.

[39] **Kovak, Brian** 2013. "Regional Effects of Trade Reform: What Is the Correct Measure of Liberalization?", *American Economic Review*, 103(5):1960-1976.

[40] **Khandelwal, Amit, Peter Schott and Shang-Jin Wei** 2013. "Trade Liberalization and Embedded Institutional Reform: Evidence from Chinese Exporters", *American Economic Review*, Vol. 103(6): 2169-2195.

[41] **Koopman, Robert, Zhi Wang, and Shang-Jin Wei** 2014. "Tracing Value-Added and Double Counting in Gross Exports", *American Economic Review*, 104(2): 459-94.

[42] **Leonhardt, D.** 2015. "College for the Masses", New Yorkt Times, Apr 24, 2015.

[43] **Michaels, Guy, Ashwini Natraj and John Van Reenen** 2014. "Has ICT Polarized Skill Demand? Evidence From Eleven Countries Over Twenty-Five Years", *The Review of Economics and Statistics*, 96(1), 60-77.

[44] **Moretti, Enrico** 2012. *The New Geography of Jobs.* New York: Houghton Mifflin Harcourt.

[45] **Pierce, Justin R. and Peter K. Schott.** 2014. "The Surprisingly Swift Decline of U.S. Manufacturing Employment", *American Economic Review*, forthcoming.

[46] **Quinton, Sophie** 2015. "Could Vocational Education be the Answer to Failing High Schools?", *The Atlantic*, Apr 15, 2015.

[47] **Schwartz, Nelson** 2013. "Where Factory Apprenticeship Is Latest Model From Germany", *New York Times*, Nov 30, 2013.

[48] **Spitz-Oener, Alexandra** 2006. "Technical Change, Job Tasks and Rising Educational Demand: Looking Outside the Wage Structure", *Journal of Labor Economics*, 24, 235-270.

[49] **The Economist** 2010. "Too narrow, too soon? Americas misplaced disdain for vocational education", June 17, 2010.

[50] **Timmermans, Bram** 2010. "The Danish Integrated Database for Labor Market Research: Towards Demystification for the English Speaking Audience", DRUID Working Papers 10-16.

[51] **Utar, Hale** 2014. "When the Floodgates Open: "Northern" Firms' Response to Removal of Trade Quotas on Chinese Goods", *American Economic Journal: Applied Economics*, 6(4): 226-250.

[52] **Utar, Hale** 2015. "Workers beneath the Floodgates: Impact of Low-Wage Import Competition and Workers' Adjustment", Bielefeld Working Papers in Economics and Management, No.12.

[53] **Utar, Hale, and Luis Torres Ruiz.** 2013. "International Competition and Industrial Evolution: Evidence from the Impact of Chinese Competition on Mexican Maquiladoras", *Journal of Development Economics*, 105: 267-287.

[54] **World Bank** 2016. World Development Indicators databese, merchandise exports.

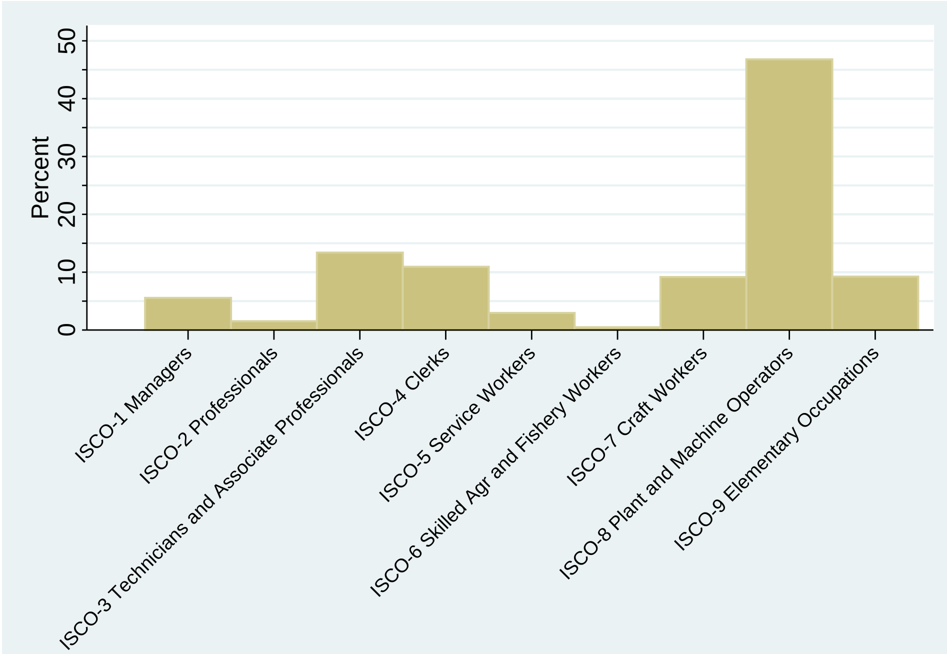
[55] **Wyman, Nicholas** 2015. "Why we desparately need to bring back vocational training in schools", *Forbes*, Sept 1, 2015.

Descriptive Statistics

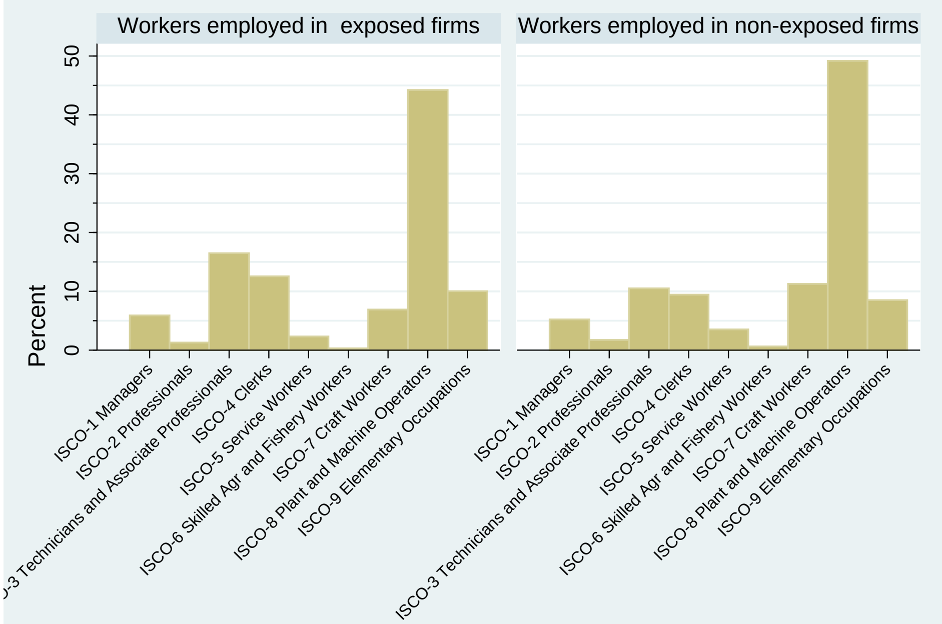
Table A-1: Ranking of Major Occupations in Denmark

Occupation	Median Log Hourly Wage		Mean Log Hourly Wage		Employment Share		Corresponding Major
	1999	2009	1999	2009	1999	2009	ISCO
High-Wage							
Legislators, Senior Officials, and Managers	5.488	5.550	5.538	5.604	0.038	0.039	1
Professionals	5.297	5.362	5.349	5.412	0.145	0.168	2
Technicians and Associate Professionals	5.116	5.177	5.160	5.211	0.184	0.239	3
Mid-Wage							
Craft and Related Trade Workers	5.053	5.098	5.002	5.034	0.128	0.091	7
Plant and Machine Operators and Assemblers	5.012	5.088	5.095	5.024	0.089	0.062	8
Clerks	4.949	5.013	4.945	5.023	0.134	0.103	4
Low-Wage							
Elementary Occupations in Sales, Services, Mining, Construction, Manufacturing, and Transport	4.919	4.962	4.928	4.956	0.117	0.104	9 (except 92)
Service Workers and Shop Sales Workers	4.849	4.938	4.851	4.927	0.165	0.193	5

Notes: Values are expressed in 2000 Danish Kroner. All hourly wages are calculated among workers with full-time jobs employed continuously with at least one year tenure. Employment shares are calculated using the number of employees and excluding army and agriculture/fishery occupations.



(a) All Workers



(b) By Import Competition

Figure A-1: Histogram of Textile Workers across Major Occupations in 1999

Table A-2: Textile Workers' Characteristics in 1999 by Selective Occupations and Import Exposure

	Mean	Standard Deviation	N
Weaving and Knitting Machine Operators employed in non-exposed firms			
Age	40.566	10.479	304
Female	0.247	0.432	304
Immigrant	0.089	0.285	304
College Educated	0.043	0.203	304
Years of Experience in the Labor Market	15.740	5.439	304
Unemployment History	1.012	1.509	304
Weaving and Knitting Machine Operators employed in exposed firms			
Age	41.966	9.459	205
Female	0.288	0.454	205
Immigrant	0.112	0.316	205
College Educated	0.049	0.216	205
Years of Experience in the Labor Market	16.493	4.813	205
Unemployment History	1.122	1.558	205
Sewing Machine Operators employed in non-exposed firms			
Age	42.849	9.368	537
Female	0.946	0.226	537
Immigrant	0.143	0.351	537
College Educated	0.020	0.142	537
Years of Experience in the Labor Market	15.294	5.579	537
Unemployment History	2.574	2.512	537
Sewing Machine Operators employed in exposed firms			
Age	43.257	10.026	915
Female	0.957	0.202	915
Immigrant	0.072	0.259	915
College Educated	0.026	0.160	915
Years of Experience in the Labor Market	16.216	5.255	915
Unemployment History Index	1.429	1.695	915
Post-Processing Textile Machine Operators employed in non-exposed firms			
Age	40.478	9.894	502
Female	0.329	0.470	502
Immigrant	0.084	0.277	502
College Educated	0.064	0.245	502
Years of Experience in the Labor Market	14.964	5.535	502
Unemployment History	1.375	1.737	502
Post-Processing Textile Machine Operators employed in exposed firms			
Age	39.030	9.667	133
Female	0.323	0.470	133
Immigrant	0.045	0.208	133
College Educated	0.030	0.171	133
Years of Experience in the Labor Market	15.609	5.145	133
Unemployment History	1.465	2.003	133
Cutting, Rope Making, Netting, Leather Textile Machine Operators in non-exposed firms			
Age	39.888	9.311	251
Female	0.199	0.400	251
Immigrant	0.008	0.089	251
College Educated	0.020	0.140	251
Years of Experience in the Labor Market	16.275	4.791	251
Unemployment History	1.713	2.117	251
Cutting, Rope Making, Netting, Leather Textile Machine Operators in exposed firms			
Age	40.466	10.201	221
Female	0.674	0.470	221
Immigrant	0.081	0.274	221
College Educated	0.032	0.176	221
Years of Experience in the Labor Market	15.330	5.396	221
Unemployment History	1.619	2.069	221