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Labour Market Polarization in Advanced Countries: Impact of Global Value Chains, Technology, Import Competition from China and Labour Market Institutions

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ABSTRACT

This paper explores the effects of offshoring, technology and Chinese import competition on labor market polarization in European countries. We find that polarization occurs mostly as a result of polarization within individual industries, while the reallocation of employment away from less polarized industries towards more highly polarized industries also contributed to a lesser extent. In manufacturing, within-industry polarization is mostly associated with technological change, but we also find some tentative evidence that Chinese import competition contributed as well. In other private industries outside of manufacturing, technological change and offshoring are the most relevant forces affecting within-industry polarization. The process of between-industry polarization is driven by widespread deindustrialization in developed countries. We find that Chinese import competition contributed to the decline of employment in the less polarized manufacturing industries. Differences in labor market institutions only explain a limited amount of cross-country variation in the association of polarization and the three forces we consider.

RÉSUMÉ

Cet article explore les effets de la délocalisation, de la technologie et de la concurrence chinoise au niveau des importations sur la polarisation du marché du travail dans les pays européens. Nous constatons que celle-ci se produit principalement en raison de la polarisation qui a lieu au sein des industries individuelles, alors que la réaffectation de l'emploi s'écartant des industries moins polarisées vers celles plus fortement polarisées y a également contribué dans une moindre mesure. Dans la manufacture, la polarisation dans l'industrie est principalement associée aux changements technologiques, mais nous trouvons également des preuves indicatives que la concurrence des importations chinoises y a également contribué. Dans d'autres industries privées hors mis la manufacture, les changements technologiques et la délocalisation sont les forces les plus pertinentes affectant la polarisation dans l'industrie. Le processus de polarisation entre les industries est lié à la désindustrialisation généralisée dans les pays développés. Nous constatons que la concurrence chinoise à l'importation a contribué au déclin de l'emploi dans les industries manufacturières moins polarisées. Les différences dans les institutions du marché du travail n'expliquent qu'une variation limitée de l'écart entre les pays dans l'association de la polarisation et les trois forces que nous considérons.

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INTRODUCTION

1. The past two decades have witnessed new global trends that shaped the economic fabric of developed economies and transformed their labor markets. One such trend is rapid technological change and the threat it poses to routine jobs through mechanization of the production process and computerization. A second trend is globalization which has manifested itself in the rise of new foreign economic powers, in particular China, and has led to increased import competition in developed economies and the restructuring of production processes in global value chains (GVCs). The emergence of China and GVCs in international trade and the swift changes in technology have led to a reexamination of the traditional way of thinking about the impacts of trade and technological change on labor markets. For instance, the ILO (2015) reports that one in five workers are estimated to work in global value chains indicating increased fragmentation of production into different activities and tasks, which is likely going to affect the relative demand and wages for skilled and unskilled workers. Similarly, Brynjolfsson and McAfee (2014) predict that in the second machine age the growth in productivity has been decoupled from jobs and income as in the digital economy a set of goods and services can be provided at a cost that is often close to zero. New technology does not inevitably reduce the overall demand for labor, but shifts demand to different kinds of work. In this context, labor markets of advanced countries have experienced substantial job polarization, with employment 'polarizing' into relatively high-skill, high-wage jobs and low-skill, low-wage jobs (Autor et al., 2006; Goos et al., 2009).

2. This U-shaped polarization pattern of the labor market is a widespread phenomenon in advanced countries. Although there is a common pattern of employment growth visible across the United States and the European Union, there are substantial differences between countries. This suggests that there is no single factor or common cause at work, but several factors that affect the shape of the labor market development, as also pointed out by Autor (2010). While job polarization was first attributed to skill-biased technological change (Autor and Katz, 1999), recent research has shifted the focus towards offshoring of routine tasks through GVCs (Oldenski, 2014), Chinese import competition (Autor et al., 2013; Keller and Utar, 2016) and to labor market institutions. Acemoglu and Autor (2011) provide evidence on how skill-biased technological change can influence the productivity of various skill groups in performing tasks in production and, hence, affect relative wages and employment shares of these skill groups. Goos et al. (2014) focus on 'routine biased technological change' and 'offshorability' of such routine tasks. The argument is that routine tasks, like those operating assembly lines, are being progressively offshored to low-wage countries, which diminishes demand for labor in the middle of the wage distribution. The model of Acemoglu and Autor (2011) can also account for 'offshorability' of tasks, which has similar effects as skill-biased technological change.

3. So far, most work has focused on the technological channel triggered by innovation and automation (e.g. Autor, 2015). Goos et al. (2014) show that the main effect comes from 'routine biased technological change' while offshorability of routine tasks has also contributed to polarization. However, Goos et al. use a subjective indicator taken from surveys to capture the 'offshorability of tasks' rather than a trade-based measure of offshoring. Moreover, their measure does not vary over time, which arguably might be important when analyzing polarization. Oldenski (2014) analyzes the impact of offshoring on polarization in the United States using a newly constructed measure, based on the total sales by a foreign affiliate of a U.S. multinational as a share of its total sales. While not much of an effect is found on average wages and employment, significant effects of both offshoring and technological change (proxied by the use of ICT) are found on polarization patterns in the U.S.

4. The role of Chinese imports in the decline of aggregate manufacturing employment in developed countries and the shift towards services has been receiving increased attention in recent years. Since the entry of China into the WTO in 2001 until the crisis in 2008, U.S. and EU manufacturing employment declined by 3.5 and 3.6 million units, respectively. Autor et al. (2013) estimate that about a quarter of the aggregate decline in U.S. manufacturing employment is due to the rise of Chinese import penetration. The findings of Donoso et al. (2014), Dauth et al. (2014) and Balsvik et al. (2013) confirm that the Spanish, German and Norwegian local labor markets that are specialized in industries competing with Chinese imports, underwent a similar fate. While it is clear that globalization has had an important impact on this process of deindustrialization, not much evidence exists on how globalization, deindustrialization and polarization are related. In a recent contribution, Keller and Utar (2016) linked the rise in Chinese imports to the decline in Danish middle-paid manufacturing jobs which has further aggravated employment polarization. As workers are pushed out of middle-paid employment in manufacturing, they transfer to low-wage services or high-wage employment. These effects hold when controlling for offshoring and technology, suggesting that Chinese import competition operates separately from these channels and is an alternative force of labor market polarization. Overall, the estimates suggest that Chinese import competition accounts for about a fifth of total mid-paid employment decline in the Danish national labor market.

5. In this paper we use a large sample of European countries to analyze the relative importance of globalization and technological change in explaining this pattern of polarization that has swept developed economies. We also explore whether differences in labor market institutions can help explain the discrepancy in polarization patterns between countries. We make a number of contributions to the growing literature on labor market polarization, globalization and technological change. First, we rely on a new measure to capture the effect of offshoring of routine tasks. We use trade in value added (TiVA), which is a measure of integration in GVCs, to analyze its impact on job polarization. The TiVA database relies on inter-country Input-Output tables to construct measures of the value added content of trade (OECD, 2016). These new trade measures have already helped in uncovering a number of important new facts: value added exports range from 50 to 90 percent of the value of exports, manufacturing trade is relatively smaller when measured in value added terms and the gap between gross exports and value added exports is quite heterogeneous across countries (Johnson, 2014). Second, we analyze job polarization in a broad range of 19 European OECD countries, including a number of Central-European countries. While a focus on wage polarization would allow one to analyze how the different forces have affected inequality, we exclusively focus on how the forces are linked to polarization of employment in high- and low-skilled jobs. Third, we simultaneously explore the effects of offshoring, technology and Chinese import competition in a large cross-country sample rather than at the individual country level. Fourth, we explore heterogeneity in labor market polarization between countries. In particular, we analyze how labor market institutions may affect polarization patterns. These institutions could affect the relative wages of different skill groups. Therefore, we would expect that the impact of both technological progress and the emergence of GVCs may be different depending on the type of regulations and wage setting institutions that prevail in various countries. To perform this analysis we analyze both manufacturing industries and private industries other than manufacturing. This allows us to tease out various relationships between the degree of involvement in GVCs, technological change, Chinese import competition, institutions and polarization at the industry level.

6. Our main findings can be summarized as follows: First, polarization is a phenomenon that is predominantly driven by polarization within individual industries. The reallocation of employment away from lowly polarized industries with relatively more mid-skill jobs, such as manufacturing, towards highly polarized industries with relatively more low- and high-skill jobs also contributes. Secondly, of the three forces we consider to explain polarization within individual manufacturing industries, technological change is the most important one, while we also find some tentative evidence that Chinese import competition also contributed. For industries outside of manufacturing, offshoring and ICT induced

technological change are the most relevant. Thirdly, we find evidence that corroborates the findings in the literature that Chinese net import competition is associated with the decline in employment in less polarized manufacturing industries. For industries outside of manufacturing there are some indications that those industries that have adopted ICT have experienced employment growth. Fourthly, labor market institutions generally perform weakly in explaining the heterogeneity in employment polarization patterns between countries. Since we do not have data on wage polarization, our findings do not exclude that labor market institutions are relevant in affecting wage polarization. Nevertheless, our results suggest that there is ample scope for policies such as skill-development programs, activation policies and sufficient social protection to facilitate smooth transition processes for affected workers.

7. The remainder of the paper is structured as follows. In the next section we discuss the data and provide some stylized facts on job polarization in various OECD countries. In section 3 we perform an econometric analysis to assess to what extent polarization is correlated with technical change, Chinese import competition and the emergence of GVCs. We focus primarily on polarization that occurs within a given industry but also analyze polarization that has occurred as a result of the reallocation of employment to more highly polarized industries. Section 4 concludes the paper.

DATA AND BASIC FACTS

Occupations and Polarization

8. Our main data source with detailed employment statistics is the harmonized European Labor Force Survey (ELFS) provided by EUROSTAT. The data contains information from 1995 to 2010 on employment status, the International Standard Occupational Classification (ISCO) codes, gender, and other major labor market characteristics of the workforce for each NACE two-digit industry within 18 European countries[1]. Since the data do not suffice to carry out an analysis on wage polarization, our analysis is entirely concentrated on the issue of employment polarization. We merge our data set with data on industry imports from the WIOD data set (Timmer et al., 2015a and 2015b) which we use to compute import competition measures. Some industries were aggregated to obtain corresponding industry definitions across the TiVA and WIOD data. For both data sets, we follow Autor and Dorn (2013) and Goos et al. (2014) and order occupations by average wage level. Having data on a detailed sectoral level rather than the more aggregated country level lends us the ability to account for the different degrees of technological change, product market competition and hence productivity growth which have an impact on demand for different skills. An additional appealing feature of our data set is the possibility to explore the heterogeneity between and within sectors[2].

9. In Table 1 we take a first look at the existence of polarization during the period from 1995 to 2010[3]. The table shows the long term pattern of labor market polarization in terms of employment shares by different occupational groups at the national level, averaged across all countries for which data were available for the entire period.

1. These countries are Austria, Belgium, Denmark, Germany, France, Finland, Greece, Portugal, Spain, The Netherlands, Great-Britain, Slovenia, Slovakia, Sweden, Czech Republic, Italy, Hungary and Ireland.

2. In 2008 the industry classification switched from NACE rev.1.1 to NACE rev.2 which causes a structural break in the ELFS database. Therefore, industry analyses are generally performed using a sample with pre-2008 data.

3. In 2011 the new ISCO08 codes were implemented and the data suffers from a structural break that cannot be overcome through concordance procedures. 2010 is thus chosen as the endpoint of our analysis here.

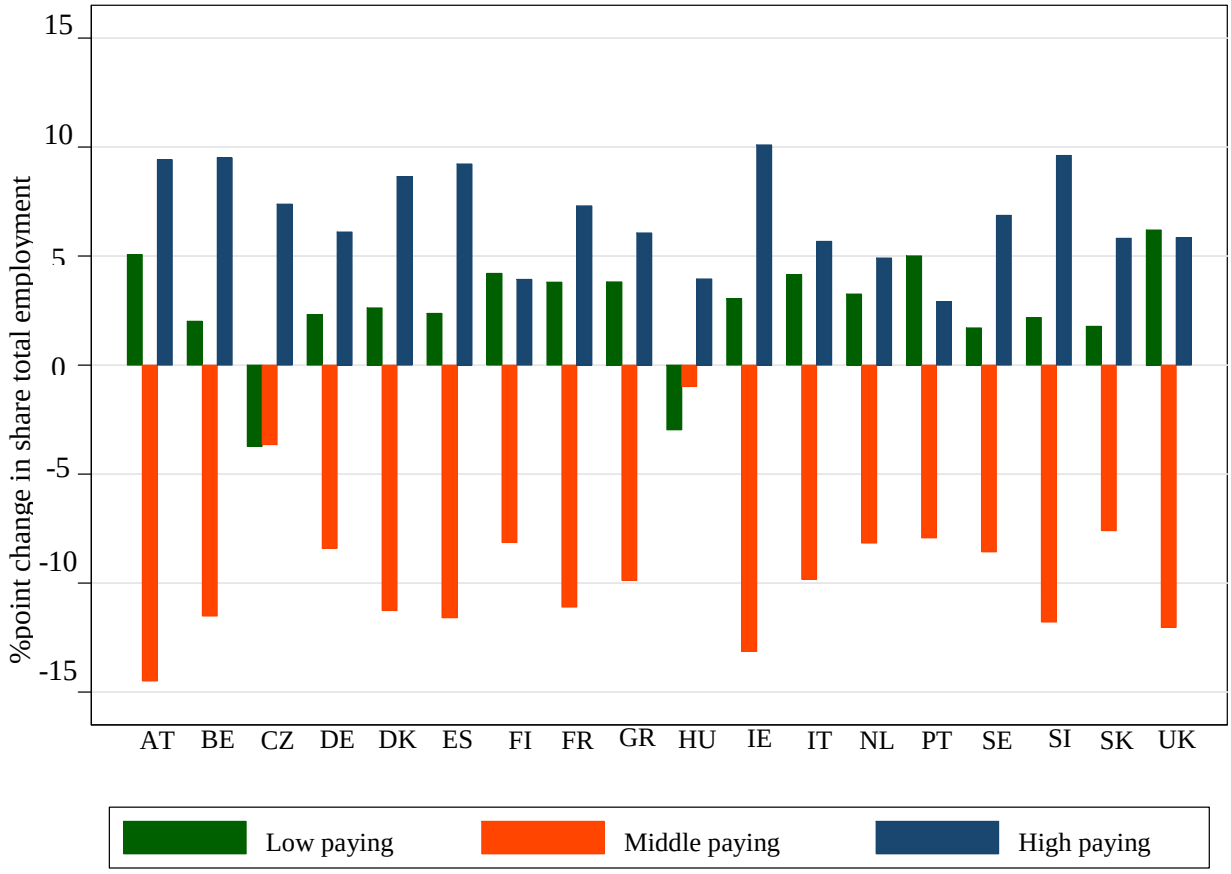
Table 1. **Average Share of Employment by major occupational groups, 1995-2010 (Europe)**

			%point change	RTI
Occupation (ISCO)	1995	2010	1995-2010	
low Paying	**24.1**	**27.9**	**3.8**	
Elementary occupations	11.0	12.3	1.3	2.11
Service and Sales Workers	13.1	15.7	2.6	-0.65
Middle Paying	**48.3**	**36.6**	**-11.7**	
Clerical Support Workers	17.6	14.9	-2.7	1.59
Craft and Related Trades Workers	18.2	12.0	-6.2	1.53
Plant and Machine Operators	12.5	9.7	-2.8	1.85
High Paying	**27.6**	**35.5**	**7.9**	
Technicians and Associate Professionals	13.7	17.0	3.3	-0.57
Professionals	8.9	12.6	3.7	-1.31
Legislators, senior officials and managers	4.9	5.9	1.0	-1.39

Note: Authors' calculations based on ELFS Data, for 12 EU countries for which data are available for the entire period 1995-2010. These countries are Austria, Belgium, Germany, Denmark, Spain, France, Great-Britain, Greece, Ireland, Italy, the Netherlands and Portugal.

10. Middle-paid occupations have declined as a share of total employment (-11.7 percentage points), while low-paid (+3.8 percentage points) and high-paid (+7.9 percentage points) occupations have gained as a share of total employment. Henceforth we shall refer to the increase of low-paid occupations relative to middle-paid occupations as low-paid employment polarization and the increase of high-paid occupations relative to mid-paid occupations as high-paid employment polarization. Table 1 also reports the Routine Task Index (RTI) used in Goos et al. (2014) and averaged by the eight occupational categories that we use. The higher the index, the more routine the tasks are considered to be. It is clear that in the middle-paid occupations this RTI index is highest, suggesting that these middle-paid occupations can be mostly considered as routine tasks. Routine tasks are more exposed to skill biased or routine biased technological change. They are also subject to offshoring because of changing relative prices and international specialization along GVCs. Table 1 reports averages across various countries. However, by using averages a lot of heterogeneity in polarization across countries is masked. This is demonstrated in Figure 1. The figure shows long-run polarization across EU countries between 1995 and 2010. In accordance with Table 1, we have grouped the employment shares of the eight occupational categories into three broad occupational groups reflecting their wage structure: low-paid, middle-paid and high-paid. The figure shows the prevalence of labor market polarization, but at the same time there are a number of noticeable differences in patterns and magnitude across countries. For instance, some of the new EU member states, like Hungary and Czech Republic, have declining shares of low-paid occupations, rather than rising shares. Most other countries follow the typical polarization pattern, but the growth rate of the various occupational shares varies between them. Although the United States is not included in our sample, statistics in the literature of this country have demonstrated that the trend is also observed along the dimensions we would expect (Katz and Margo, 2014). Figure 2 shows this using a more detailed breakdown of occupations based on the American Community Survey.

Figure 1. **Heterogeneity in polarization, EU countries, 1995-2010**



Source: Authors' calculations based on ELFS

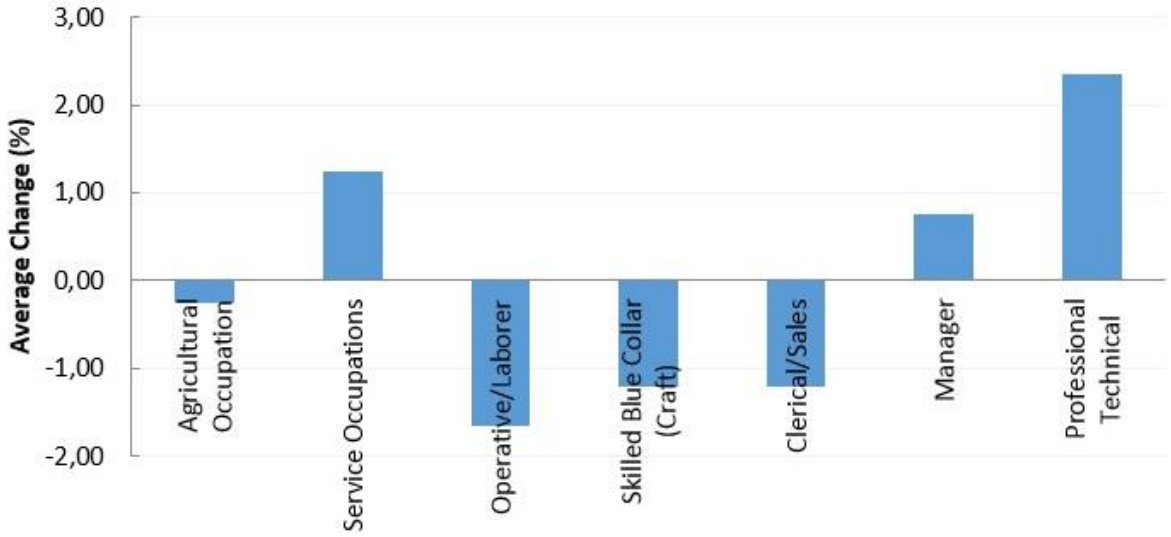
Within-sector and between-sector polarization

11. The increase in polarization that we observe at the national level can occur as a result of polarization within individual industries or employment shifting away from industries that are initially lowly polarized to industries that are more polarized. The latter type of polarization might be particularly of interest given the decline of manufacturing and the shift towards services in developed economies.

Figure 2. **Polarization in the United States**

Average Change per Decade in US occupational Employment Shares for 1999-2010

Sorted From Low Paying to High Paying



Source: based on Katz and Margo (2014), Table 1.6, panel A and own calculations

12. In Table 2, we report the average polarization by NACE one-digit industry in 1997 and 2007[4,5]. Employment polarization is computed by dividing the sum of low- and high-skilled employees by the total number of employees in an industry. As before, we divide occupations into skill groups in accordance with Goos et al. (2014)[6]. The table reveals that polarization has risen in nearly every industry. Interestingly, the table also reveals that there are large differences in the average level of polarization between the different industries. For instance, manufacturing is a relatively low-polarized industry whereas real estate and business services is on average amongst the more polarized industries in the EU.

13. To understand the contribution of within-industry polarization and structural shifts between industries, we decompose overall polarization of a country *c*, $Polar_c$, into a within- and between-industry term as also done by Goos et al. (2014). We then analyze the relevance of each factor. Although we do not have any data on non-European countries, the large set of European countries that are included in the sample allow us to make some general statements on polarization at the industry level. In our econometric analysis in section 3 we mostly focus on polarization in both two-digit manufacturing industries and one-digit non-manufacturing industries. For the purposes of analyzing broad shifts across sectors in this section, one-digit industries are preferable.

4. The included sectors are Agriculture; Mining; Manufacturing; Electricity, gas and water supply; Construction; Wholesale and retail trade; Hotels and restaurants; Transport, storage and communication; Financial intermediation; and Real estate, renting and business activities; Public administration; Education; Health and social work; Other services.

5. We chose 1997 as the initial year because data for some countries are missing in 1995 and 1996. Since observations for Slovakia in the ELFS start from 1998 onwards, we use 1998 to compute the averages of that country for 1997. We set 2007 as the final year of our analysis since the NACE industry codes changed in 2008 causing a structural break in the series.

6. see Table 1.

Table 2. **Average polarization by industry in 1997 and 2007**

Industry	Fraction of high- and low-paid employees in total employment	
	1997	2007
Agriculture	0.49	0.52
Mining	0.30	0.34
Manufacturing	0.32	0.37
Electricity, gas, water supply	0.41	0.50
Construction	0.25	0.27
Wholesale and retail trade	0.67	0.71
Hotels and restaurants	0.91	0.91
Transport and Communication	0.33	0.37
Financial intermediation	0.54	0.64
Real Estate and business services	0.71	0.78
Public administration	0.67	0.74
Education	0.77	0.82
Health and Social work	0.88	0.90
Other Services	0.72	0.75

Source: Authors' calculations based on ELFS data. Simple (unweighted) averages computed across all countries in the sample.

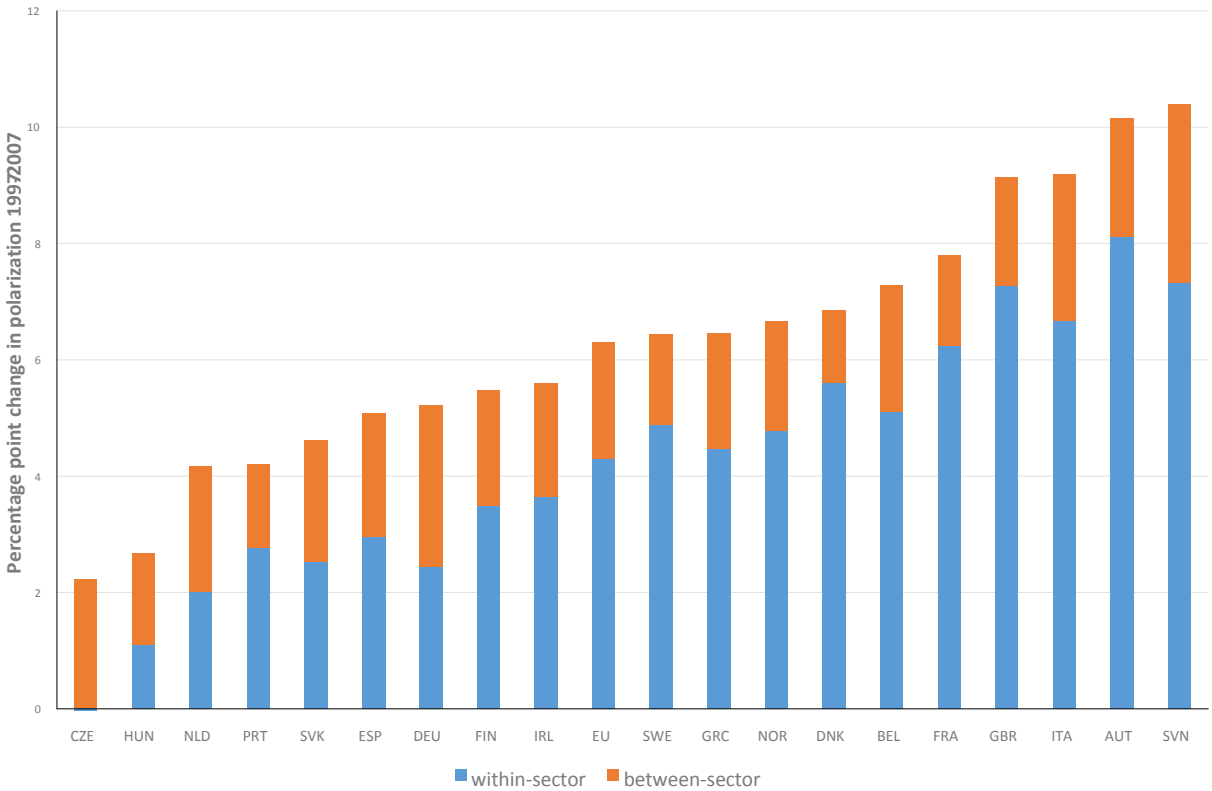
$$\Delta Polar_c = \underbrace{\sum_i \Delta Polar_{\mathrm{i,c}} \overline{S}_{\mathrm{i,c}}}_{\text{Within-term}} + \underbrace{\sum_i \Delta S_{\mathrm{i,c}} \overline{Polar}_{\mathrm{i,c}}}_{\text{Between-term}}$$

14. Where $Polar_{i,c}$ is the within-industry polarization and $S_{i,c}$ is the employment share of the industry relative to total employment in all considered industries of country c. The change is computed over the period of 1997 to 2007. In Figure 3 we show the results of this decomposition by country and list the average for the European countries in the middle of the graph.

15. The existence of heterogeneity in cross-country polarization patterns that we reported earlier is again emphasized in the results of the decomposition. Moreover, both the increase in polarization within individual industries and the reallocation of employment towards more highly polarized industries is causing overall national polarization. However, the within-industry component is the most important contributor to overall polarization. On average, it explains 68%, or 4.3 percentage points, of the 6.3 percentage points increase of low- and high- paid employment in total employment in the European countries. The average contribution of each sector to the overall within-industry polarization term are examined in Table 3. Similar to what was reported in Table 2, we find that almost all industries are contributing positively to the overall within-industry polarization. This implies that within-sector polarization persistently features across all industries of the economy rather than being limited to a few individual industries. Although there is some variation across countries in the general contribution of each

industry to the total within-sector polarization term, manufacturing and wholesale and retail trade generally appear as the largest overall contributors[7].

Figure 3. **Within/between-sector decomposition of polarization**



Source: Authors' calculations based on ELFS

16. Meanwhile, the reallocation of employment away from manufacturing as a result of deindustrialization in high-income countries and towards industries such as business services and health and social work drives the between-industry term. Hence, based on this evidence, manufacturing plays a prevalent role in explaining overall polarization. Moreover, as will be shown presently, manufacturing has also been highly susceptible to Chinese import competition, offshoring and technological change.

Technological change, Global Value Chains and Institutions

17. Since we want to relate polarization across sectors and countries to skill/routine-biased technological change, the offshoring-potential of routine jobs and Chinese import penetration, we introduce various proxies at the industry-country level. Although we study these three forces as separate factors affecting the overall pattern of polarization, Marcolin et al. (2016) have noted that there are complex interactions between trade, technology and skills. They argue that this makes it difficult to clearly establish whether GVCs have a positive or a negative impact on specific categories of workers. The objective of our analysis is consequently not to formulate causal relationships between our three forces and the phenomenon of polarization but rather to study the conditional correlations of each of these factors with industry polarization.

7. We have done the same within/between-decomposition at the manufacturing level. There, the within-industry term explains around 92% of total polarization on average, leaving little to be explained by reallocation of employment between the individual manufacturing industries of a country.

Table 3. **Average individual sector contributions to within/between decomposition from 1997 to 2007 (expressed in percentage points)**

Industry	Within	Industry	between
Hotels & Restaurants	-0.023	Manufacturing	-1.407
Mining	0.020	Financial Intermediation	-0.244
Agriculture	0.057	Public Administration	-0.206
Other Services	0.107	Electricity, gas, water	-0.182
Electricity, gas, water	0.117	Agriculture	-0.161
Education	0.153	Transport & Communication	-0.131
Construction	0.157	Mining	-0.063
Health & Social work	0.212	Education	0.050
Transport & Communication	0.304	Other Services	0.071
Financial Intermediation	0.389	Construction	0.222
Business Services	0.528	Wholesale & Retail trade	0.487
Public Administration	0.567	Hotels & Restaurants	0.699
Wholesale & Retail trade	0.568	Health & Social work	0.681
Manufacturing	1.133	Business Services	2.185
Total average contribution	4.290	**Total average contribution**	2.002

Source: Authors' calculations based on ELFS data. Simple (unweighted) averages computed across all countries in the sample.

18. To capture technological change or innovation we rely on two different proxies. First, we use the R&D intensity of a sector taken from the OECD statistics database (OECD, 2016). This variable relates the R&D expenditure in a sector to the value added that is generated in that same industry.

$$R\&D\ Intensity_{ict} = \frac{R\&D_{ict}}{VA_{ict}} \qquad (2)$$

19. Where $R\&D_{ict}$ is the R&D expenditure in industry i of country c during year t and VA_{ict} is the value added generated by that same industry during that time. The use of R&D as a proxy for technological change is predicated on a rich literature that has aimed to relate process and product innovation at the firm-level to employment changes. Specifically, Klette and Forre (1998) and, more recently, Bogliacino et al. (2012) both used R&D expenditure to proxy for innovation. Interestingly, Bogliacino et al. also found that R&D as a proxy for innovation not only mattered for firms in manufacturing industries but also for firms active in services industries. This strengthens our belief that R&D expenditure can also be used as a trustworthy proxy for technological innovation in non-manufacturing industries. In light of the findings of Goos et al. (2016), we use the ICT capital services per hour worked, ICT_{ict}, from EU Klems as an additional indicator of technological change. Goos et al. (2016) show that there is a positive correlation between the intensity of ICT capital use and the measured polarization within the industry. In contrast with R&D Intensity, which is a measure of technological innovation particularly relevant within manufacturing, ICT capital intensity is a measure of technology adoption that shows great variation both across manufacturing and non-manufacturing industries. It could hence provide additional insights into how technological changes have affected polarization.

20. We use the TiVA measure from the OECD and WTO (2016) to capture the integration of an industry in GVCs and hence the likelihood that tasks are more easily 'offshorable'. The indicators are derived from the 2015 version of OECD's Inter-Country Input-Output (ICIO) Database. We use the foreign value added share embedded in the gross exports of each industry and in each country as the main indicator that captures offshoring. Equation 3 presents this formally:

$$TiVA_{ict} = \frac{FVA\ Exports_{ict}}{Exports_{ict}} \qquad (3)$$

21. Where $FV\ AExports_{ict}$ represents the foreign value added in the gross exports of industry *i* in country *c* at time *t* and $Exports_{ict}$ are the gross exports of that same industry. A higher value indicates that an industry relies more on international specialization and hence international fragmentation of the production process, reflecting comparative advantages across industries and countries. An increase in the share of foreign value added in a industry's exports reflects the industry's growing susceptibility to the globalization of its production chain. If this results in middle-skilled jobs being offshored abroad, then polarization will increase as a direct result. However, data on the foreign component of value added in exports in the TiVA database is not available annually for all years of our sample. The data is available only for 1995, 2000, 2005, and the period 2008-2011. In order to improve the sample size, we have used linear interpolation to fill in the missing data. In Table A1 in appendix A we show that both in terms of the initial levels of GVC involvement and the evolution over the time frame 1995 to 2010 countries show great heterogeneity.

22. As a measure of Chinese import penetration we use the share of Chinese imports in total industry domestic absorption[8], calculated on the basis of the WIOD database (Timmer et al., 2015a and 2015b). Formally, we present this is as:

$$Imp.pen_{ict}^{CHN} = \frac{IMP_{ict}^{CHN}}{Dom.abs_{ict}} \qquad (4)$$

23. Where IMP_{ict}^{CHN} are the Chinese imports of industry *i* goods by country *c* at time *t* and $Dom.abs_{ict}$ is domestic absorption of the industry. A higher value of this variable indicates the greater importance of Chinese goods in overall domestic consumption in the industry. These Chinese imports compete with domestic output and thus lead to the loss of jobs in those industries that are most exposed. If this loss of jobs is primarily concentrated on middle-skill jobs, as evidence by Keller and Utar (2016) suggests, then polarization in the industry should increase as a direct result. In Figure A1 in appendix A, we present the change in Chinese import penetration from 1995 to 2007 by country for the private economy and for manufacturing. The graph shows that manufacturing industries have been highly exposed to Chinese imports. Moreover, the change in exposure has varied across countries. Central-European countries in particular have seen the largest increase in Chinese import penetration over the period. Given the findings in the literature for the U.S. labor market and several European labor markets, manufacturing employment is likely affected by increased Chinese import competition in each economy as a result of this rise in Chinese imports.

24. Finally, we supplement our data with several additional country-level indicators on institutions from the OECD databases. In particular, we are interested in how labor market regulation, such as

8. Domestic absorption reflects the domestic consumption of an industry's goods. It is computed as:

$$Dom.absict = GOict + IMPict - EXPict$$

where GOjct is the gross output of an industry i of country c during year t, IMPict are the imports by country c during year t of industry i goods produced in other countries and EXPict are the exports by industry i in country c during year t.

employment protection legislation, unionization, minimum wages, etc. might dampen or strengthen the evolution in job polarization. These variables will allow us to control for differences in the respective market conditions when assessing the effects of technology and globalization on the polarization of the labor market. We present summary statistics for all main variables included in our regression samples in Tables A2 and A3 of appendix A.

25. In Table 4 we explore the relationship between the main components of our decomposition and GVC, R&D intensity, ICT and Chinese import penetration. We report the simple average of the change employment and the change in within-sector polarization, the average level of GVC intensity, ICT, R&D intensity and Chinese import penetration across all countries in the sample[9]. Since data on R&D intensity are unavailable for public sector industries, agriculture and mining, we only report statistics for non-agriculture and non-mining private industries. The table shows that manufacturing is strongly integrated in GVCs, experiences strong Chinese import competition and also has a high R&D and ICT intensity. Chinese import competition and process innovation through R&D expenditure are relatively unimportant factors in non-manufacturing industries[10]. However, the level of ICT capital intensity varies substantially across non-manufacturing industries. The financial intermediation and the business service sector are particularly exposed to ICT-related technological change.

Table 4. **The link between GVCs, technology and Chinese import penetration with within-industry polarization change (over period 1997-2007)**

Industry	$\Delta Polar$	$\Delta emp.$	$OFFSH$	$R\&Dintensity$	ICT	$Imp.pen_{ict}^{CHN}$
Construction	2.62	0.60	23.78	0.14	2.43	0.18
Electricity, gas, water supply	10.14	-0.34	26.12	0.37	18.12	0.07
Financial intermediation	8.99	-0.23	9.787	0.42	69.19	0.03
Hotels and restaurants	-0.40	0.61	16.45	0.00	5.96	1.27
Manufacturing	5.31	-4.26	36.40	4.89	8.77	1.76
Real estate and business serv.	5.15	2.51	14.34	1.00	24.13	0.16
Transport and communication	3.35	-0.34	20.74	0.46	19.00	0.47
Wholesale and retail trade	3.09	0.70	14.59	0.23	9.71	0.30

Source: Author's calculations based on ELFS data. Simple (unweighted) averages computed across all countries in the sample

26. In our analysis we have thus far not dealt with the unobserved differences between the industries of different countries that are constant over time. It is therefore imperative that we control for these factors accordingly in a more detailed analysis. Moreover, our analysis has also highlighted the pivotal role of some industries in overall national polarization as well as the disparate exposure of industries to the forces of globalization and technological change. Manufacturing in particular stands out in this respect. By lumping both manufacturing and non-manufacturing industries together and analyzing the statistical relationship with the different forces, we might therefore misinterpret how these are related. In our empirical analysis, we shall therefore divide our sample into a subsample of manufacturing and non-manufacturing industries and analyze these separately.

9. We no longer weight each observation according to the average employment level as in equation 1.

10. Acemoglu et al. (2016) show that these industries are mostly indirectly exposed to Chinese import competition shocks through their industrial linkage with domestic manufacturing firms.

EMPIRICAL FRAMEWORK AND RESULTS

27. We first outline the empirical framework and then show our results on within-industry polarization. We then briefly discuss the results on between-industry reallocation of labor.

Empirical framework

28. The standard framework to think about polarization is the canonical model of Acemoglu and Autor (2011), which distinguishes between different skill groups of workers each performing a subset of production tasks, which are imperfectly substitutable. In their model, innovation takes the form of factor-augmenting technological progress either favoring high or low-skilled workers, resulting in increasing wage inequality between skill groups. Their model focuses mainly on skilled-biased technological change. However, they also discuss the implications when certain tasks in production are being offshored to a foreign country. Oldenski (2014) shows how offshoring changes the relative wages and employment shares. In particular, skill-augmenting technological progress affects the productivity of high-skilled workers, which allows them to increase the range of tasks they can carry out, at the expense of middle-skilled occupations. Offshoring of routine tasks changes the composition of skills and hence the range and productivity of these tasks, which adds to increased wage inequality and polarization. So, in this case offshoring reinforces skill-biased technological change. Goos and Manning (2014) coin this as 'routine biased technological change (RBTC)'. Keller and Utar (2016) highlight the role of international trade as an additional pertinent factor of employment polarization. They offer empirical evidence that offshoring induces low-wage employment polarization, whereas technological change mainly increases high-wage employment. Hence, only if both factors are considered together does one obtain the full pattern of polarization. However, import competition from China contributes through changes at all wage levels. It displaces workers from the middle-wage employment abundant manufacturing industry towards the more polarized services industries.

29. We specify two reduced form equations that include these three forces, one focusing on the share of workers (*N*) in high-paid (*h*) relative to middle-paid (*m*) occupations, $\frac{N_h}{N_m}$; and the second one aiming at the share of workers in low-paid (*l*) occupations to middle-paid (*m*) ones, $\frac{N_l}{N_m}$. We order occupations according to average wage level in line with Goos et al. (2014). Through our specifications, we capture the observed within-industry polarization and correlate it to our indicators of technological change, offshoring and Chinese imports[11]. Similar set-ups have been used by Autor and Dorn (2013), Oldenski (2014), Keller and Utar (2016) and others. Thus, we seek to estimate the following specifications and variations of them:

$$\ln\left(\frac{N_h}{N_m}\right)_{\text{ict}} = \alpha_1 + \alpha_2 \ln TiVA_{\text{ict}} + \alpha_3 \ln R\&D\ Intensity_{\text{ict}} + \alpha_4 \ln ICT_{ict} + \alpha_5 \ln Imp.pen_{ict}^{CHN} + \alpha_6 \boldsymbol{L}_{ct} + \theta_{ic} + \epsilon_{ict}$$

$$\ln\left(\frac{N_l}{N_m}\right)_{\text{ict}} = \alpha_1 + \alpha_2 \ln TiVA_{\text{ict}} + \alpha_3 \ln R\&D\ Intensity_{\text{ict}} + \alpha_4 \ln ICT_{ict} + \alpha_5 \ln Imp.pen_{ict}^{CHN} + \alpha_6 \boldsymbol{L}_{ct} + \theta_{ic} + \eta_{ict}$$

11. In terms of equation 1, we try and explain the ΔPolar term and use the industry shares as weights.

30. With subscript i, c and t referring to industry, country and year, respectively. θ_{ic} are country×industry fixed effects and ϵ_{ict} and η_{ict} are the error terms. These specifications allow us to analyze how the employment structure within industries has on average been affected by the change in technology, import competition and offshoring. We expect that α_2, α_3, α_4 and α_5 (β_2, β_3, β_4 and β_5 respectively) have a positive effect on the share of high- (low-)paid occupations on average. The dependent variables and *TiVA*, *R&DIntensity*, *ICT* and $Imp.pen^{CHN}$ are measured in logarithms, which facilitates the interpretation of the coefficients as they refer to elasticities.

31. Our regression specifications will be augmented with indicators of labor market institutions, indicated by the vector **L**, which includes in particular union density, OECD index of employment protection legislation[12] and an adjusted Kaitz index[13,14]. There are good reasons to believe that labor market institutions have a dampening impact on polarization. Typically, when there is wage-setting in labor markets, either through bargaining with trade unions or some other mechanism like monopsony or efficiency wage payments, a more compressed wage structure tends to emerge (e.g. Acemoglu and Pischke (1999), Manning (2003), Konings and Vanormelingen (2015)). This implies that productivity effects are not fully passed on into wages. Therefore, changes in relative wages between different occupational groups are likely to be lower when productivity shocks occur that are triggered by technological progress and organizational aspects in GVCs. So, this suggests that polarization will be less pronounced in countries with strong unions and labor market regulations.

32. At the same time, however, the internationalization of the production process into GVCs is likely to have implications for union power as pointed out by Rodrik (1997), Slaughter (2001) and Konings and Vandenbussche (1995). Since the outside option for firms changes when integration in GVCs becomes more entrenched, firms may find it easier to offshore part of their production to low wage countries. Simultaneously, the rise in import competition from China leads to employment losses in the manufacturing industry and downsizing. Hence, unions see their bargaining power reduced, which in turn would amplify polarization. The overall effect is a priori therefore not clear. Empirically, we will analyze these channels by interacting our indicators of globalization, GVCs and Chinese import competition, with measures capturing labor market institutions.

33. The evidence in section 2.2 suggested that most of the observed aggregate polarization is a consequence of within-sector polarization. Nevertheless, a substantial fraction of overall polarization is accounted for by reallocation between industries within the broader economy. To understand the role of GVCs, import competition and technology in overall polarization, we require an additional specification that relates changes in the employment of industries in the economy to these factors. The empirical approach of Acemoglu et al. (2016) offers a useful framework that analyzes the effect of Chinese import competition on employment. Their empirical model is not oriented towards uncovering the reallocation of employment but rather quantifies the effects of a shock on employment.

34. By applying this approach to our analysis, we obtain insights into the effects of GVCs, import competition and technology on the general industrial structure of the economy. Acemoglu et al. use two

12. We take the index of strictness of employment protection for temporary contracts. We have also experimented with the employment protection legislation for temporary and fixed contracts, but the results do not change qualitatively.

13. The Kaitz index is constructed as the ratio of the minimum wage over the average wage in a country c at time t. The index is adjusted to reflect the absence of a federal minimum wage in several of the countries in the sample. We set the value of the index to zero when a formal minimum wage does not exist at any moment during year t.

14. We have also experimented with using collective bargaining coverage from the ICTWSS database of Visser (2015) as an additional proxy for the strength of labor market institutions. Since there are several missing values in this variable and the results do not seem to change qualitatively when it is included, we have not incorporated it in our main specification.

multi-year stacked periods over which they compute the changes in Chinese import exposure for individual industries and found that greater exposure had a negative impact on the employment of manufacturing industries. Since the time dimension of our data is not of the same length as that of Acemoglu et al., we compute the change in GVC participation, import competition of China and R&D intensity over one long pre-crisis period and over a smaller post-crisis period[15]. Subsequently, we perform the analysis using two separate specifications: one where we exclusively consider the long pre-crisis period and one where we consider both the pre- and the post-crisis periods. The specification where we exclusively use the long pre-crisis period is of the following form[16]:

$$\Delta \ln E_{ict} = \gamma_1 + \gamma_2 \Delta \ln TiVA_{ict} + \gamma_3 \Delta R\&D\ Intensity_{ict} + \gamma_4 \Delta lnICT_{ict} + \gamma_5 \Delta Imp.pen._{ict}^{CHN} + \delta_c + \omega_{ict}$$

35. $\Delta \ln E_{ict}$ is the percentage change in the employment of an industry. δ_c is a country fixed effect included to control for a general country employment trend. By controlling for the country fixed effects we concentrate on growth differentials between industries within the countries. We replace the country fixed effect with a country×period fixed effect, δ_{ct} when considering both the pre- and the post-crisis period. Each observation is weighted with the beginning of period employment share in national employment. Since the main regressors are both reported in logs the coefficients can again be directly interpreted as an elasticity. The ex-ante expected sign on both γ_2, γ_3 and γ_4 is ambiguous. Although γ_2 might be positive if an industry has managed to successfully integrate itself in the GVC and experience increasing employment as a result, it is likely to be negative if the $TiVA$ measure captures increased upstream offshoring by domestic firms or import penetration of industrial goods. Similarly, increasing technological intensity could signal that industry's path to successfully compete on both the domestic and the foreign markets. However, if industries invest in labor-saving technology, γ_3 and γ_4 could also be associated with decreasing employment. γ_5 is expected to be negative based on extensive evidence in the literature on the effects of Chinese import competition on employment (e.g. Autor et al., 2013; Acemoglu et al., 2016).

Within-industry Results

36. First, we discuss the baseline results of the within-industry polarization. Thereafter, we explore the cross-country heterogeneity of the results. We then introduce a number of additional experiments and robustness checks.

Baseline Results

37. By including all available sectors in one specification, we stand to lose a large fraction of underlying variation which in turn would make it more difficult to find any statistical relationships in the data. In Tables 5 and 6 we split our sample in two subsamples. In Table 5 we report results for a detailed subsample of manufacturing industries defined at the NACE rev.1.1 two digit level, while in Table 6 we limit our sample to all non-manufacturing private industries defined at the NACE rev.1.1 one digit level (excluding agriculture and mining). In section 2.2 we noted that polarization in manufacturing industries is almost entirely explained by within-sector polarization and that the sector has been highly exposed to the forces of technology and globalization. Given this difference in exposure between manufacturing and non-manufacturing industries, a separate analysis for each group of industries is helpful in establishing whether the role of GVCs, Chinese import competition and technology differed between manufacturing industries and non-manufacturing industries. All the subsequent estimations in this section are performed using

15. The structural break in the data in 2008 caused by a change in the NACE industry classification is circumvented by choosing a pre-crisis sample with NACE 1.1 industry classification and a post-crisis sample with NACE 2 industry classification.

16. In terms of equation 1 we explain the changes in the employment shares, δSi,c, by investigating the relationship between the different explanatory factors and industry employment, Eict.

industry×country fixed effects, so the identification occurs through variation over time. Each observation is weighted by the share of sector employment in total private employment.

38. The results in columns (1) and (2) of Table 5 report a specification where we only consider R&D intensity as a measure for technology. In columns (3) and (4) we only consider ICT as the proxy for technological change. Independent of the chosen technology proxy, we find that offshoring, technological change and Chinese import penetration are all correlated with high-paid employment polarization. However, both technology variables might be capturing different aspects of technological change. Therefore, we estimate a specification including both variables in columns (5) and (6). Interestingly, both technology variables enter significantly thus indicating that both variables might indeed capture different aspects of technological change. The coefficients imply that a 10 percent change in the R&D intensity of a manufacturing industry is correlated with an increase in high-paid employment polarization of 0.9 percent, while an equiproportional rise in the ICT intensity of an industry is associated with a 2 percent rise in high-paid employment polarization. We no longer find proof that involvement in GVCs is linked to polarization. However, a 10 percent rise in Chinese import competition is correlated with a 1.1 percent rise in high-paid employment polarization. The latter correlation shows that globalization is also highly relevant for within-industry polarization in manufacturing industries, in line with the evidence provided by Keller and Utar (2016). We do not find empirical evidence that any of the three forces are associated with low-paid employment polarization, thus unveiling an asymmetry with which the forces affect employment polarization at the high and the low end of the pay-scale. We will explore this asymmetry in more detail during the robustness checks. We also find that the effect of labor market institutions is not strongly correlated with polarization. Therefore our priors on the role of labor unions are not confirmed. We also anticipated that employment protection and the relative measure of minimum wages have dampening effects on the reallocation process in response to shocks, but we find no strong evidence that these measures significantly affect the polarization process. The asymmetry with which the different forces affect high- and low-paid employment polarization is notable. We return to this issue in the discussion of the robustness checks.

39. In columns (7) and (8) we include a country-specific time trend in our specification. Given the structure of our data, this specification is highly demanding. The accession of China to the WTO in 2001 triggered a rise in offshoring and Chinese imports which any time trend will automatically capture. By including the trend we thus run the risk of being left with insufficient variation to identify our indicators of globalization[17]. The literature uses detailed industry level data to overcome this obstacle and ensure sufficient variation is available for proper identification. While our data offers the advantage of covering multiple countries, it comes at the price of having industrylevel data at a more aggregated level. Nevertheless, we still find that ICT remains strongly correlated with high-paid employment polarization, but Chinese import competition and R&D intensity no longer show a significant statistical relationship. Hence, our results suggest there is strong evidence for ICT-induced technological change being associated with employment polarization, while our evidence on the relevance of R&D related technological change and Chinese import competition is more of a tentative nature.

Next, we turn our attention to the other subsample of non-manufacturing private sectors in our data[18]. The results for this subsample are reported in Table 6. We proceed similarly as before by first only introducing the R&D measure as a proxy for technology in columns (1) and (2). We find no clear proof

17. The use of linear interpolation to connect missing year data points of the TiVA measure also means that some variation allowing independent identification of the effect of offshoring on polarization is lost.

18. The private sectors included in the sample are the NACE rev. 1.1 one digit sectors electricity, gas and water supply; construction; wholesale and retail trade; hotels and restaurants; transport, storage and communication; financial intermediation; real estate, renting and business activities. We thus exclude agriculture and mining from the analysis.

that technological change is linked to either high- or low-paid employment polarization. This is not surprising as the statistics in Table 4 showed that the R&D intensity of most non-manufacturing industries is generally low. In column (3) and (4) we include ICT as an alternative proxy. This variable varies a lot more across the different non-manufacturing industries and the results show that ICT is positively correlated with high-paid employment polarization. In columns (5) and (6) we again combine both technology proxies. Our results indicate that a 10 percent rise in GVC involvement is correlated with a rise of 3.1 percent in low-paid employment polarization. However, the results suggest that offshoring is not linked with a rise in high-paid employment polarization which again points towards an asymmetric relation between the three forces and low-paid and high-paid employment polarization. A 10 percent rise in the ICT intensity of an industry leads to a rise of 1.7 and 0.9 percent in high- and low-paid employment polarization, respectively. There is also a small statistical association between Chinese import competition and low-paid employment polarization. A rise of 10 percent in Chinese import competition leads to a rise of 0.1 percent in polarization at the low-end of the pay-scale. However, note here that nonmanufacturing industries could be indirectly affected by Chinese import competition through their industrial links with manufacturing industries Acemoglu et al. (2016). We explore this possibility in the robustness checks[19]. In columns (7) and (8) we include a more conservative estimation strategy with country×year fixed effects. Again we find that much of the significance of our coefficients is lost.

40. The results in Tables 5 and 6 show the merit of splitting our sample into a manufacturing and non-manufacturing subsample. The manufacturing industries have experienced a distinct type of exposure to the different technological and globalization forces compared to non-manufacturing industries. Chinese import competition and process innovation through changes in ICT and R&D intensity were important contributors to within-industry polarization in manufacturing industries. Given the diverse nature of industries included in the group of non-manufacturing industries, it is likely that the exposure to globalization and technological change could still have had idiosyncratic effects on certain industries in this group. However, we lack sufficient detail to explore this issue at depth.

19. Similarly, technological shocks could equally reverberate from manufacturing to non-manufacturing industries, although we do not examine this possibility any further here.

Table 5. **Explaining polarization using manufacturing sector data (NACE two digit) in the period 1996-2007**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	top	bottom	top	bottom	top	bottom	top	bottom
TiVA	0.26**	-0.03	0.30*	-0.02	0.24	-0.08	-0.11	-0.27
	(0.12)	(0.23)	(0.16)	(0.23)	(0.15)	(0.24)	(0.15)	(0.33)
R&D intensity	0.07**	0.06			0.09***	0.05	0.03	-0.01
	(0.03)	(0.03)			(0.02)	(0.05)	(0.03)	(0.03)
ICT			0.23***	0.15	0.20***	0.07	0.13**	0.01
			(0.04)	(0.12)	(0.05)	(0.09)	(0.06)	(0.08)
$Imp.pen^{CHN}$	0.14***	0.09	0.11***	0.09	0.11***	0.10	0.02	0.06
	(0.02)	(0.05)	(0.03)	(0.06)	(0.03)	(0.06)	(0.02)	(0.04)
Union Density	-0.43	1.24	0.91	1.94	0.80	1.69		
	(0.70)	(1.93)	(0.56)	(2.40)	(0.58)	(2.44)		
EPL	-0.02	0.00	0.04	0.04	0.03	0.01		
	(0.07)	(0.17)	(0.08)	(0.17)	(0.07)	(0.17)		
Adjusted Kaitz	0.09	0.37	-0.13	0.22	-0.08	0.31		
index	(0.10)	(0.23)	(0.10)	(0.32)	(0.11)	(0.25)		
Constant	-1.85***	-2.46*	-2.52***	-2.84***	-2.31***	-2.51*	-0.73	-1.20
	(0.48)	(1.17)	(0.56)	(1.29)	(0.56)	(1.31)	(0.52)	(1.10)
Industry× country FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country× Year FEs	No	No	No	No	No	No	Yes	Yes
R^2	0.942	0.785	0.933	0.790	0.932	0.794	0.948	0.885

Note: Standard errors in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Estimates based on manufacturing sectors (NACE two digit). Standard errors clustered at the country level. All variables are expressed in logs with the exception of the adjusted Kaitz index and labor union density. Observations are weighted. The dependent variable *top* is the ratio of high-paid employees over mid-paid employees. The dependent variable *bottom* is the ratio of low-paid employees over mid-paid employees. All results robust to excluding the petroleum and nuclear fuel industry.

41. Due to the aggregated nature of our industry-level data and the concomitant issue of identification when including a time trend, we will use a specification such as the one in columns (5) and (6) of Tables 5 and 6 as our main model throughout the remainder of the within-industry polarization analysis. Based on our estimates so far, we conclude that the results are at least partially consistent with the theoretical models, such as Acemoglu and Autor (2011) and others, where the trigger is labor augmenting

technological progress benefiting the high-skilled tasks, at the expense of middle-skilled tasks. During the time period we consider in our analysis, we witness strong changes in ICT capital services per hour worked. These grew around eight and twelve times larger in non-manufacturing and manufacturing industries, respectively. Normally, the high complementarity between high-skill and low-skill tasks suggests technological change also benefits the latter, but we find only weak proof that low-paid employment polarization is linked to technological change. The effects of globalization have manifested themselves differently depending on the type of industries we consider. While we find that Chinese import competition is correlated with employment polarization towards high-paying jobs in manufacturing, our results indicate that among non-manufacturing industries GVC participation is associated with employment polarization towards low-paying jobs. For manufacturing these findings reflect the rapid rise of Chinese import competition in manufacturing industries which increased on average from 0.84 percent of total domestic absorption in 1996 to 3.28 percent in 2007.

Table 6. **Explaining polarization using broad sector non-manufacturing data (NACE one digit) in the period 1996-2007**

	(1) top	(2) bottom	(3) top	(4) bottom	(5) top	(6) bottom	(7) top	(8) bottom
TiVA	0.22	0.18	0.26**	0.47***	0.16	0.31***	-0.12	0.25
	(0.15)	(0.14)	(0.10)	(0.14)	(0.16)	(0.10)	(0.18)	(0.24)
R&D intensity	0.02	-0.00			0.01	-0.01	-0.00	0.03*
	(0.02)	(0.01)			(0.02)	(0.01)	(0.01)	(0.01)
ICT			0.16***	0.07	0.17***	0.09*	-0.09	-0.06
			(0.04)	(0.06)	(0.04)	(0.04)	(0.11)	(0.11)
Imp.pen^{CHN}	0.00	0.01**	0.01	0.02	0.01	0.01*	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Union Density	-2.51**	-0.33	-0.62	1.17	-1.01	0.74		
	(0.91)	(0.54)	(0.95)	(0.68)	(1.06)	(0.66)		
EPL	-0.03	-0.02	0.03	0.07	0.03	0.05		
	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.03)		
Adjusted Kaitz	0.28*	0.30	0.07	0.40**	0.13	0.23		
Index	(0.15)	(0.18)	(0.07)	(0.14)	(0.12)	(0.14)		
Constant	-1.85***	-2.46*	-2.52***	-2.84***	-2.31***	-2.51*	-0.73	-1.20
	(0.48)	(1.17)	(0.56)	(1.29)	(0.56)	(1.31)	(0.52)	(1.10)
Industry× country FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country× Year FEs	No	No	No	No	No	No	Yes	Yes
R^2	0.977	0.983	0.971	0.983	0.976	0.985	0.989	0.989

Notes: Standard errors in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Estimates based on non-manufacturing private sectors (NACE one digit) excluding agriculture and mining industries. Standard errors clustered at the country level. All variables are expressed in logs with the exception of the adjusted Kaitz index and labor union density. Observations are weighted. The dependent variable *top* is the ratio of high-paid employees over mid-paid employees. The dependent variable *bottom* is the ratio of low-paid employees over mid-paid employees.

42. In Table 7 we show the results of interacting TiVA and Chinese import competition with measures of labor market institutions, such as Union Density, EPL and Minimum Wages. When we account for potential interactions between labor market institutions and each of the different forces affecting employment, the table shows that there are some interesting interactions. High labor union

density and employment protection legislation in manufacturing industries that are highly exposed to the force of globalization are associated with greater high-paid employment polarization. In non-manufacturing industries we find that higher minimum wages mitigate low-paid job polarization in industries more exposed to Chinese import penetration. Based on these results, labor market institutions do play some role in observed polarization patterns, though overall their contribution appears weak. In our robustness checks, we will explore this further.

Table 7. **Explaining polarization within-industry polarization in the period 1996-2007: Interaction of offshoring measure and Chinese import penetration with labor market institutions**

Manufacturing			**Non-Manufacturing**	
	(1)	(2)	(3)	(4)
TiVA	-0.23	-0.64	0.07	0.14
	(0.24)	(0.43)	(0.23)	(0.22)
R&D intensity	0.09***	0.05	0.01	-0.01
	(0.02)	(0.05)	(0.02)	(0.01)
ICT	0.20***	0.06	0.19***	0.10**
	(0.06)	(0.09)	(0.04)	(0.04)
$Imp.pen^{CHN}$	0.14*	0.17	0.05	0.04**
	(0.07)	(0.19)	(0.04)	(0.02)
Union Density	-2.73	-3.96	-1.08	-0.87
	(2.03)	(3.50)	(1.56)	(1.47)
TiVA×Union Density	1.02*	1.74	0.11	0.62
	(0.53)	(1.23)	(0.54)	(0.42)
Imp.pen^{CHN}×Union Density	-0.04	-0.08	-0.02	0.00
	(0.12)	(0.32)	(0.06)	(0.03)
EPL	-0.11	-0.41	0.11	0.26
	(0.59)	(1.28)	(0.26)	(0.15)
TiVA×EPL	0.06	0.12	-0.02	-0.08
	(0.17)	(0.38)	(0.09)	(0.06)
$Imp.pen^{CHN}$×EPL	0.03*	-0.05	-0.00	-0.01
	(0.02)	(0.04)	(0.01)	(0.01)
Adjusted Kaitz index	-0.72	0.68	-0.73	0.34
	(0.79)	(1.32)	(0.70)	(0.32)
TiVA×Adjusted Kaitz index	0.19	-0.11	0.09	-0.18
	(0.19)	(0.31)	(0.18)	(0.16)
$Imp.pen^{CHN}$×Adjusted Kaitz Index	-0.10	-0.05	-0.15	-0.11**
	(0.11)	(0.28)	(0.09)	(0.04)
Constant	-0.72	-0.69	-0.37	-1.55**
	(0.90)	(1.31)	(0.81)	(0.70)
N	1937	1932	809	809
Industry×country FEs	Yes	Yes	Yes	Yes
Year FEs	No	No	No	No
*R*2	0.934	0.797	0.977	0.986

Notes: Standard errors in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Standard errors clustered at the country level. All variables are expressed in logs with the exception of the adjusted Kaitz index and labor union density. Observations are weighted. The dependent variable *top* is the ratio of high-paid employees over mid-paid employees. The dependent variable *bottom* is the ratio of low-paid employees over mid-paid employees.

Differences across country groups

43. In Table 8 we relax the assumption that the effects that globalization and technological change have are of common nature and size across all countries in our sample. Differences in industrial structure, favorable economic headwinds through further integration with the rest of the European economy and institutional differences across countries may have meant that the employment polarization, though common across all economies, might have different relationships with offshoring, import competition and technology depending on the group of countries one is analyzing. Our findings suggest that high- and low-paid polarization in core Western-European countries are correlated with technological change as captured by ICT intensity for both manufacturing and non-manufacturing industries. However, in Central and Southern European countries the correlation between ICT intensity and polarization is often a lot weaker. ICT adoption in Central European countries has thus decreased within-industry polarization rather than increased it. In Western European manufacturing industries high- and low paid polarization is also correlated with process innovation through R&D intensity. However, R&D intensity is not associated with low-paid employment polarization in other country groups. We also find that Chinese import competition is linked with low-paid employment polarization in the manufacturing sector of most country groups. However, in Central European countries the opposite is again true. The differing patterns in associations between technology, Chinese import penetration and polarization show that countries are not uniformly affected by the same globalization and technology forces. Moreover, the results also indicate that the different forces are correlated with both high- and low-paid employment polarization in Western Europe and, to a lesser extent, in Northern European countries. Hence, the apparent asymmetry in how the globalization and technology forces correlate with high- and low-paid employment polarization that was apparent in Table 5 and 6 are the result of differences between country groups.

44. In Table B1 of appendix B we analyze how the interaction of within-industry polarization and the technology and globalization forces differs in countries that are characterized by strong labor market institutions. The results indicate that low-paid employment polarization in manufacturing industries is considerably more sensitive to offshoring in countries with strong labor market institutions. Whereas a 10% change is not associated with a significant increase in low-paid employment polarization for the countries in the sample with below median labor market institutions, it is associated with a 9.2% increase for the countries with above median labor market institutions. However, low-paid employment polarization is also lessened in the same manufacturing industries with strong ICT intensity changes. When looking at these results in conjunction with the results in Table 7, we conclude that there is no straightforward relation between labor market institutions and polarization. The highly varying nature of the results in Table B1 point towards other underlying factors that are determining how sensitive industries are to within-industry polarization. Hence, industries in different countries seem to show differing degrees of sensitivity to globalization and technological forces independent of the type of labor market institutions these countries have.

Table 8. **Explaining polarization using manufacturing sector data in the period 1996- 2007: Differences across country groups**

	Manufacturing	**Non-manufacturing**	(3)	(4)
	(1)	(2)	Top	Bottom
	Top	Bottom		
TiVA	0.25	0.29	0.01	0.23
	(0.36)	(0.39)	(0.29)	(0.16)
TiVA*Scand.&A-Saxon	-0.31	-0.99	-0.06	-0.37
	(0.42)	(0.63)	(0.32)	(0.22)
TiVA*Central Europe	-0.48	-1.19	-0.51	0.15
	(0.45)	(0.95)	(0.31)	(0.27)
TiVA*Southern Europe	0.23	0.39	0.66	0.23
	(0.63)	(0.37)	(0.40)	(0.36)
R&D intensity	0.08**	0.28***	0.04	-0.00
	(0.03)	(0.08)	(0.04)	(0.01)
R&D*Scand.&A-Saxon	-0.00	-0.29**	-0.06	-0.01
	(0.04)	(0.10)	(0.04)	(0.02)
R&D*Central Europe	-0.02	-0.21**	-0.02	0.03
	(0.04)	(0.09)	(0.04)	(0.04)
R&D*Southern Europe	0.08*	-0.19**	-0.03	0.04*
	(0.04)	(0.08)	(0.04)	(0.02)
ICT	0.27***	0.21*	0.24***	0.09**
	(0.06)	(0.11)	(0.03)	(0.03)
ICT*Scand.&A-Saxon	-0.07	-0.18	-0.08	0.26**
	(0.11)	(0.18)	(0.06)	(0.09)
ICT*Central Europe	-0.36**	-0.62**	-0.36**	-0.02
	(0.13)	(0.28)	(0.14)	(0.06)
ICT*Southern Europe	-0.17*	-0.33**	-0.22***	-0.22**
	(0.10)	(0.11)	(0.03)	(0.09)
Imp.pen^{CHN}	0.08***	0.13*	-0.01	0.02
	(0.02)	(0.07)	(0.02)	(0.02)
Imp.pen^{CHN}*Scand.&A-Saxon	-0.02	-0.01	0.03	0.01
	(0.06)	(0.13)	(0.03)	(0.03)
Imp.pen^{CHN}*Central Europe	-0.05	-0.48*	0.01	-0.02
	(0.04)	(0.23)	(0.02)	(0.02)
Imp.pen^{CHN}*Southern Europe	0.07	-0.15	0.04	0.00
	(0.09)	(0.15)	(0.03)	(0.02)
Union Density	-0.75	-1.44	-1.83	0.99*
	(0.90)	(2.29)	(1.16)	(0.55)
EPL	0.13*	0.23	0.07	0.04
	(0.07)	(0.14)	(0.05)	(0.04)
Adjusted Kaitz index	-0.15*	0.06	0.11	-0.14
	(0.08)	(0.24)	(0.11)	(0.16)
Constant	-1.19	-0.96	0.19	-1.79***
	(0.73)	(1.50)	(0.86)	(0.43)

	Manufacturing (1) Top	**Non-manufacturing** (2) Bottom	(3) Top	(4) Bottom
N	1937	1932	809	809
Industry× country FEs	Yes	Yes	Yes	Yes
Country×Year FEs	No	No	No	No
R^2	0.937	0.829	0.978	0.986

Notes: Standard errors in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Estimates based on manufacturing (NACE two digit) sectors in columns (1) and (2) and non-manufacturing (NACE one digit) sectors excluding agriculture and mining in columns (3) and (4). Standard errors clustered at the country level. Observations are weighted. Countries in our sample are divided into four different geographic groups: Scandinavian and Anglo-Saxon countries (Denmark, Finland, Norway, Sweden, United Kingdom and Ireland), core Western-European countries (Austria, Belgium, France, Germany and Netherlands), Southern-European countries (Spain and Italy) and Central-European countries (Czech Republic, Hungary and Slovenia).

Robustness checks

45. In this section we carry out a number of robustness checks of our within-industry polarization estimations. We start by using various measures to capture GVCs. We first proceed by discussing the results of the manufacturing industries before looking at the non-manufacturing industries. Columns (1) and (2) in Table 9 report our baseline results with our standard proxy for the involvement of industries in GVCs, the foreign value added in domestic exports, expressed as TiVA1. This measure is an indicator of backward participation of the industry in the GVC. The domestic industry is seen as a middle chain in the GVC that produces goods containing foreign value added that are sold in foreign markets. Therefore, the measure is a close proxy for offshoring as an increasing foreign share in the domestic exports signals that a larger fraction of the industrial activities is performed in other countries. We proxy GVCs in columns (3) and (4) by an alternative measure of GVC participation, TiVA2, that captures the forward participation of an industry in GVCs. For this measure the value added generated by the industry and embedded in foreign exports is divided by total exports of the industry. The domestic industry is assumed to be at the beginning of the GVC producing intermediate inputs for foreign exporters. As a result, the measure is not directly capturing offshoring but rather the effect of upstream GVC participation on polarization. We find no significant relation between GVC forward participation and polarization. In column (5) through (8) we use the same measures of backward and forward participation, renamed respectively TiVA3 and TiVA4, but scale them relative to gross output of the industry to account for the fact that an industry might only export a small fraction of its output. Throughout all specifications in Table 9 there is no indication that offshoring is significantly linked with employment polarization. R&D intensity, ICT intensity and Chinese import competition are significant and very precisely estimated throughout all specifications for high-paid employment polarization.

46. In Table 10 we use the same set of TiVA measures and test the robustness of our baseline estimation for non-manufacturing industries. Since we found that offshoring is statistically linked with a rise in low-paid employment polarization, we can test if this finding also holds for forward participation in GVCs or if it is exclusively associated with backward participation in GVCs. The results suggest that only backward-GVC participation is relevant for the process of low-paid employment polarization. Moreover, the effect of backward GVC participation is weaker once we scale the foreign value added in exports relative to the gross output of the industry (columns (5) and (6)), but the coefficient is still significant. Forward participation is statistically linked to high-paid employment polarization in non-manufacturing industries in column (7). However, this result depends on the scaling of the TiVA measure since the result in column (3) is insignificant and it is therefore insufficiently robust.

Table 9. **Explaining polarization using manufacturing sector data in the period 1996 - 2007: Alternative TiVA measures for offshoring**

	(1) top	(2) bottom	(3) top	(4) bottom	(5) top	(6) bottom	(7) top	(8) bottom
TiVA1	0.24	-0.08						
TiVA2			0.03	0.03				
TiVA3					-0.03	-0.19		
TiVA4							0.03	-0.01
R&D Intensity	0.09***	0.05	0.09***	0.05	0.10***	0.06	0.09***	0.05
ICT	0.20***	0.07	0.20***	0.06	0.20***	0.07	0.20***	0.07
Imp.pen^{CHN}	0.11***	0.10	0.11***	0.10	0.12***	0.10	0.11***	0.10
Constant	-2.31***	-2.51*	-1.50***	-2.87***	-1.39***	-2.42**	-1.49***	-2.79**
N	1937	1932	1937	1932	1937	1932	1937	1932
Industry×Country FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country×Year FEs	No	No	No	No	No	No	No	No
*R*2	0.932	0.794	0.932	0.794	0.932	0.796	0.932	0.794

Notes: Standard errors in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Estimates based on manufacturing sectors (NACE two digit). Standard errors clustered at the country level. All variables are expressed in logs with the exception of the adjusted Kaitz index and labor union density. Observations are weighted with the share of employment in the sector relative to total national manufacturing employment. The dependent variable *top* is the ratio of high-paid employees over mid-paid employees. The dependent variable *bottom* is the ratio of low-paid employees over mid-paid employees.

In column (1) and (2) standard TiVA measure: Foreign value added in domestic gross exports relative to gross domestic exports.

In column (3) and (4) the TiVA measure is the total domestic value embodied in the exports of foreign countries expressed as a fraction of domestic gross exports.

In column (5) and (6) foreign value added in domestic exports are expressed as a fraction of gross output rather than gross domestic exports.

In column (7) and (8) domestic value added in foreign exports are expressed as a fraction of gross output rather than gross domestic exports.

Table 10. **Explaining polarization using non-manufacturing sector data in the period 1996-2007: Alternative TiVA measures for offshoring**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	top	bottom	top	bottom	top	bottom	top	bottom
TiVA1	0.16	0.31***						
TiVA2			0.01	-0.03				
TiVA3					0.02	0.11*		
TiVA4							0.16*	0.14
R&D Intensity	0.01	-0.01	0.01	-0.00	0.01	-0.00	0.01	-0.00
ICT	0.17***	0.09*	0.18***	0.10**	0.18***	0.09**	0.16***	0.08*
Imp. pen^{CHN}	0.01	0.01*	0.01	0.01*	0.01	0.01*	0.01	0.01
Constant	-0.65	-2.06***	-0.21	-1.04*	-0.17	-1.22***	-0.25	-1.21***
N	809	809	809	809	809	809	809	809
Industry× country FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country×Year FEs	No	No	No	No	No	No	No	No
*R*2	0.976	0.985	0.976	0.985	0.976	0.985	0.977	0.985

Notes: Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Estimates based on non-manufacturing sectors (NACE one digit). Standard errors clustered at the country level. All variables are expressed in logs with the exception of the adjusted Kaitz index and labor union density. Observations are weighted with the share of employment in the sector relative to total national manufacturing employment. The dependent variable *top* is the ratio of high-paid employees over mid-paid employees. The dependent variable *bottom* is the ratio of low-paid employees over mid-paid employees. Computation different TiVA measures explained in footnotes Table 9.

47. We now test the robustness of the Chinese import competition measure and again proceed first by analyzing manufacturing industries. In columns (1) and (2) we present our baseline results. In column (3) and (4) we not only consider import competition from China, but also from other low-income countries (LIC)[20]. The overall correlation between import penetration and high-paid employment polarization remains significant when we use this newly constructed import penetration measure. In columns (5) to (8) we again use Chinese import competition but also account for the increased export opportunities that the emergence of China on the world stage might have presented. In column (5) and (6) we therefore include Chinese export penetration. We discuss the construction of this variable in appendix B. The sign of the coefficient implies that the new export opportunities presented by China are associated with a decrease in within-industry polarization. However, the coefficient is not statistically significant at the conventional levels. In columns (7) and (8) we combine the Chinese import competition and Chinese export opportunities measure in a net import competition measure. A rise of 10 percent in net imports of a manufacturing industry increases employment polarization at the high-end of the labor market by 0.2 percent.

20. Beside China, we also consider India, Indonesia, Mexico and Turkey.

Table 11. **Explaining polarization using manufacturing sector data in the period 1996-2007: Testing impact of import penetration of China and other developing countries**

	(1) top	(2) bottom	(3) top	(4) bottom	(5) top	(6) bottom	(7) top	(8) bottom
TiVA	0.24	-0.08	0.28*	-0.04	0.24	-0.07	0.36**	0.02
R&D intensity	0.09***	0.05	0.10***	0.06	0.09***	0.05	0.09***	0.06
ICT	0.20***	0.07	0.23***	0.09	0.21***	0.08	0.25***	0.11
$Imp.pen^{CHN}$	0.11***	0.10			0.11***	0.10		
$Exp.pen^{CHN}$					-0.01	-0.02		
Net $Imp.pen^{CHN}$							0.02*	0.01
Union Density	0.80	1.69	0.59	1.48	0.73	1.53	0.33	1.26
EPL	0.03	0.01	0.02	0.00	0.03	0.01	0.01	-0.01
Adj. Kaitz	-0.08	0.31	-0.09	0.30	-0.07	0.32	-0.07	0.31
$Imp.pen^{LIC}$			0.09**	0.07				
Constant	-2.31***	-2.51*	-2.46***	-2.66*	-2.31***	-2.51*	-2.64***	-2.80*
N	1937	1932	1937	1932	1937	1932	1937	1932
Industry×Country FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	No	No	No	No	No	No	No	No
R^2	0.932	0.794	0.931	0.793	0.932	0.794	0.930	0.792

Notes: Standard errors in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Estimates based on manufacturing sectors (NACE two digit). Standard errors clustered at the country level. All variables are expressed in logs with the exception of the adjusted Kaitz index and labor union density. Observations are weighted with the share of employment in the sector relative to total national manufacturing employment. The dependent variable *top* is the ratio of high-paid employees over mid-paid employees. The dependent variable *bottom* is the ratio of low-paid employees over mid-paid employees. $Imp.pen^{LIC}$ is the import penetration from the developing countries China, India, Indonesia, Mexico and Turkey.

48. The non-tradable nature of the output of several non-manufacturing industries and the limited increase in Chinese services imports have meant that non-manufacturing EU industries have generally not faced direct Chinese import competition. However, several of these industries are indirectly exposed to a Chinese import penetration shock as they provide services that are used as an input by the manufacturing industries. Hence, the demise of manufacturing industries at the hands of manufacturing imports from China leaves non-manufacturing industries exposed through their industrial links with manufacturing industries. Indeed, Acemoglu et al. (2016) and Acemoglu et al. (2015) show that a shock to manufacturing industries situated downstream in the production chain of a non-manufacturing industry, reduces that industry's employment significantly. Here we wish to analyze how downstream exposure to Chinese import competition affects non-manufacturing within-industry employment polarization[21]. The construction of our downstream exposure measure is discussed in appendix B. The industrial links between the industries are derived from the WIOD I/O-Tables (Timmer et al., 2015a and 2015b). In Table 12 we present our baseline results in columns (1) and (2). In columns (3) and (4) we use the indirect exposure to Chinese import penetration in the domestic manufacturing industries[22]. However, the result is not

21. We return to the effects of indirect exposure to downstream shocks on industry employment later.

22. We have also experimented with the indirect exposure to Chinese import penetration in all EU manufacturing industries and not just the domestic manufacturing industries. This is particularly relevant for small

statistically significant and does not carry the anticipated sign. In columns (5) and (6) we use the indirect exposure to net import penetration. Again, we find no significant results. Some caution remains warranted in interpreting these results. Our indirect exposure measures were computed using aggregated industry level data. If one were to use more disaggregated data, the indirect exposure measure would become more precisely determined. However, currently our analysis indicates that within-industry polarization in non-manufacturing industries is not associated with indirect exposure to Chinese import penetration while it is only weakly associated with direct Chinese import penetration.

49. Technological change can be measured in a number of ways. Thus far we have used the ICT intensity and the R&D intensity of a sector. However, a possible comment to the use of the latter variable as an indicator of technological change is that it measures technology input and therefore does not necessarily capture technological output and, hence, technological change. We perform a robustness check to test a specification using a variable that also reflects process innovation but that is more closely related to technological output. In particular, we use the number of patents per employee in the industry as a proxy for technological change. Given the limited relevance of R&D to non-manufacturing industries, we limit our robustness check to manufacturing industries. Table 13 reports the results. In columns (1) and (2) we report the results from our main specification with R&D intensity as a proxy for technological change; in columns (3) and (4) the patent variable is used. The patent variable shows no correlation with the polarization measure. Import competition from China and ICT intensity remain robustly estimated for high-paid employment polarization.

50. We now briefly discuss several other robustness checks that we have performed and that are presented in appendix B[23]. One worry concerning our dependent variable is that the pattern of employment polarization using employment statistics might differ from the pattern of specialization based on total hours worked. If a rise in the number of low- or high-paid employees is simultaneously accompanied by a decrease (increase) in the average number of hours these employees perform, then we are overestimating (underestimating) the pattern of polarization of actual work performed. To control for this issue, we compute the total hours worked per skill group and use this in our regressions as a dependent variable. The ELFS reports the total number of employees and the approximated average number of hours worked each week for every skill group in every two-digit industry. Table B2 reports the results and shows that our findings are robust to this new definition of the dependent variable.

WesternEuropean countries such as Belgium, the Netherlands and Austria that are more tightly economically integrated with neighboring economies. All results are robust to using this different specification of the indirect exposure measure.

23. Although not reported, we have also attempted to control for potential correlation in the error terms of the high-paid and the low-paid employment polarization equations by using seemingly unrelated regressions. The results are robust to using this estimation technique.

Table 12. **Explaining polarization using non-manufacturing sector data in the period 1996-2007: Testing impact of downstream exposure to Chinese import penetration**

	(1)	(2)	(3)	(4)	(5)	(6)
	top	bottom	top	bottom	top	bottom
TiVA	0.16	0.31***	0.26*	0.30**	0.26	0.30**
R&D intensity	0.01	-0.01	-0.01	-0.02*	-0.00	-0.02
ICT	0.17***	0.09*	0.18***	0.13***	0.18***	0.13***
Imp.pen^{CHN}	0.01	0.01*				
Indirect Imp.pen^{CHN}			-0.02	-0.02		
Indirect Net Imp.pen.^{CHN}					-0.07	-0.07
Union Density	-1.01	0.74	-0.52	0.88	-0.58	0.83
EPL	0.03	0.05	0.05	0.05	0.06	0.06*
Adjusted Kaitz index	0.13	0.23	0.10	0.21	0.09	0.20
Constant	-0.65	-2.06***	-1.20	-2.19***	-1.18	-2.17***
N	809	809	892	892	892	892
Industry× country FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	No	No	No	No	No	No
R^2	0.976	0.985	0.976	0.985	0.977	0.985

Notes: Standard errors in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Estimates based on non-manufacturing sectors (NACE one digit). Standard errors clustered at the country level. All variables are expressed in logs with the exception of the adjusted Kaitz index and labor union density. Observations are weighted with the share of employment in the sector relative to total national manufacturing employment. The dependent variable *top* is the ratio of high-paid employees over mid-paid employees. The dependent variable *bottom* is the ratio of low-paid employees over mid-paid employees. $Imp.pen^{CHN}$ is the import penetration from China. . $Indirect\ Imp.pen^{CHN}$ is the downstream exposure to import penetration from China through the industrial links with domestic manufacturing industries.

$Indirect\ Net\ Imp.pen^{CHN}$ is the downstream exposure to net import penetration from China through the industrial links with domestic manufacturing industries.

51. So far, all our specifications were estimated using panel data with annual observations. Since polarization has taken place over a period of several years, any underlying statistical relationship between polarization and the different forces should emerge over longer periods as well. To look at these longer term relations and account for the hidden long-term dynamics, we repeat our analysis in three ways using a variety of long and stacked differences. The results are reported in Table B3 for manufacturing industries and B4 for non-manufacturing industries[24]. We find some evidence that technology through R&D intensity and Chinese import competition are associated with polarization in manufacturing industries, but we do not find empirical proof that any of the forces are significantly associated with within-industry polarization in the non-manufacturing industries. We also find that the post-2008 period was exceptional.

Table 13. **Explaining polarization using manufacturing sector data in the period 1996-2007: patents/employee as alternative measure of technology**

	(1)	(2)	(3)	(4)

24. Since we have no data post-2007 on the ICT intensity of the industries, we are unable to include this important variable in the analysis.

	top	bottom	top	bottom
TiVA	0.24	-0.08	0.31*	-0.04
R&D intensity	0.09***	0.05		
ICT	0.20***	0.07	0.21***	0.08
Imp.pen^{CHN}	0.11***	0.10	0.11***	0.10*
Union Density	0.80	1.69	0.98	1.75
EPL	0.03	0.01	0.03	0.01
Adjusted Kaitz Index	-0.08	0.31	-0.14	0.27
Patent/employee			0.05	-0.00
Constant	-2.31***	-2.51*	-2.72***	-2.61**
N	1937	1932	1937	1932
Industry× country FEs	Yes	Yes	Yes	Yes
Year FEs	No	No	No	No
R^2	0.932	0.794	0.931	0.794

Notes: Standard errors in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Estimates based on manufacturing sectors (NACE two digit). Standard errors clustered at the country level. All variables are expressed in logs with the exception of the adjusted Kaitz index and labor union density. Observations are weighted with the share of employment in the sector relative to total national manufacturing employment. The dependent variable *top* is the ratio of high-paid employees over mid-paid employees. The dependent variable *bottom* is the ratio of low-paid employees over mid-paid employees.

Between-industry results

52. The reallocation of employment across the broad NACE one-digit industries accounted on average for 32% of total polarization and thereby complemented the polarization that occurred within individual industries. In section 2.2 we showed that the deindustrialization of economies substantially contributed to between-industry polarization as employment shifted towards more polarized industries. Two explanations offered by the literature for the process of deindustrialization are the relatively faster growth in manufacturing productivity in advanced economies (Rowthorn and Ramaswarmy, 1999) and the process of globalization marked among other things by the penetration of Chinese imports in advanced economies (Pierce and Schott, 2012; Autor et al., 2013). Given the complexity of the issue at hand and the difficulty in finding true underlying causal relationships, we again limit our approach to searching for statistical relationships. We are interested in the statistical link of globalization and technological change with changes in the employment of industries. Both increased GVC integration and Chinese import competition are symptoms of globalization, while technological change through R&D investments and increased use of ICT can induce faster manufacturing productivity growth and can be seen as a test of the Rowthorn and Ramaswarmy (1999) hypothesis. As before, we concentrate on both manufacturing industries and non-manufacturing industries. Some industries in manufacturing have been particularly exposed to Chinese import competition and offshoring. Focusing exclusively on these industries might reveal further insights into the role of the different forces on the employment losses in these industries. Our estimates might be subject to concerns of endogeneity as reported by Autor et al. (2013) and Acemoglu et al. (2016). This issue could be particularly severe in our specification since our sample includes several countries. If the country and the country×time fixed effects are unable to properly control for local demand effects, the Chinese import competition coefficient will be upwardly biased since a demand boom will raise both employment and imports in some sectors. Given that there are several countries in our sample which have undergone such demand-driven booms, the issue is likely pervasive.

Therefore, we limit our between-industry analysis to basic specifications and leave a more rigorous approach to future research. We report the results in Table 14.

Table 14. **Explaining employment growth using broad sector and manufacturing sector data in the period 1998-2010**

	Manufacturing		Non-manufacturing	
	(1)	(2)	(3)	(4)
	$\Delta ln(emp)$	$\Delta ln(emp)$	$\Delta ln(emp)$	$\Delta ln(emp)$
TiVA	0.29	0.02	0.28	-0.21
	(0.26)	(0.23)	(0.20)	(0.20)
R&D intensity	-0.05	-0.05	0.06	0.04
	(0.07)	(0.03)	(0.04)	(0.02)
ICT	-0.12		0.28*	
	(0.09)		(0.14)	
Imp.penCHN	0.02	0.04	0.04	0.01
	(0.01)	(0.03)	(0.03)	(0.01)
Constant	0.09	-0.32***	-0.32***	0.01
	(0.13)	(0.02)	(0.14)	(0.06)
N	139	345	51	131
Country FEs	Yes	No	Yes	No
Country×period FEs	No	Yes	No	Yes
R^2	0.225	0.194	0.441	0.428

Notes: Estimates based on manufacturing (NACE two-digit) sectors in columns (1) and (2) and non-manufacturing NACE two-digit industries in columns (3) and (4). Standard errors clustered at the country level. All variables are expressed in logs. Observations are weighted by beginning of period employment share in national employment. The dependent variable is the change in the log of employment. Petroleum and nuclear fuel industry is excluded from the analysis.

Column (1) and (3): Long differences from 1998 to 2007.

Column (2) and (4): Stacked differences from 1998 to 2007 and 2008 to 2010.

53. In column (1) we look at long differences over the period from 1998 to 2007. Interestingly, none of our three forces have significant coefficients. In column (2) we include the crisis period observations and estimate the model with two stacked periods from 1998 to 2007 and from 2008 to 2010[25]. Since we have no data on ICT intensity after 2007, this indicator of technological change was excluded from any analysis that included the crisis period. A problem with a specification including the crisis period is that GVC participation, Chinese imports, R&D intensity and employment could have simultaneously decreased as a result of the particular severity of the crisis in some countries. The correlation we would thus obtain would be spurious and add little understanding to the links between our regressors and employment polarization. To control for the country-specific time effect, we therefore replace our country fixed effects with country×period fixed effects in column (2). We do not find statistical proof that any of our regressors is correlated with changes in employment. In columns (3) and (4) we present the estimates for the non-manufacturing industries. In Table 3 it was shown that some industries contributed to between-industry polarization while others did not as employment slumped. We now wish to understand which factors are associated with these diverse employment trends between industries. The results in column (3) suggest that ICT related technological change increased employment in non-manufacturing industries. Since we do not have data on ICT intensity after 2007 we are not able to check the robustness of this findings.

25. Considering that the NACE industry classification changed in 2008, the stacked periods also ensure that the industry definitions are consistent within each of the two stacked periods.

54. In appendix B we constructed a net import penetration measure. Through considering both negative exposure to China due to import competition and positive exposure as a result of rising exports to the Chinese market, we are possibly in a better position to explain employment growth differences between industries. Indeed, results by Dauth et al. (2014) suggest that German regions that were highly exposed to import competition from both China and Eastern-Europe suffered a decline in manufacturing employment, while other regions specializing in industries that benefited from the increased access to foreign markets experienced employment growth. The use of net import penetration is also more suitable as it distinguishes between industries that are heavily exposed to import competition and those that have become more integrated in the world economy, leading to a simultaneous growth in imports and in exports. Although our analysis of withinindustry polarization demonstrated that the results were largely indifferent to the use of a net import penetration measure, we nevertheless wish to understand whether this distinction in measurement matters here. In Table 15 we therefore present the results from performing the same analysis as the one in Table 14 but this time with the net import penetration measure.

55. Of the three forces we considered, the net import penetration of an industry is most correlated with decreasing employment in manufacturing. The estimates in column (1) indicate that a ten percent increase in net import penetration is associated with a 0.2 to 0.3 percent decrease in employment. However, we do not find any evidence that Chinese net import penetration was relevant for employment changes in non-manufacturing industries, while ICT is only significantly correlated with employment changes at the 12% level for these industries. Hence, we have some indications that ICT may have been an important factor in determining the between-industry reallocation of employment that has increased employment polarization. In appendix B we explore how the indirect exposure to net import competition in manufacturing industries is correlated with non-manufacturing employment growth. However, our analysis does not show any statistical association between these variables.

Table 15. **Explaining employment growth using broad sector and manufacturing sector data in the period 1998-2010: Chinese net import penetration measure**

	Manufacturing		Non-manufacturing	
	(1)	(2)	(1)	(2)
	$\Delta ln(emp)$	$\Delta ln(emp)$	$\Delta ln(emp)$	$\Delta ln(emp)$
TiVA	-0.06	-0.09	-0.05	-0.43
	(0.35)	(0.22)	(0.24)	(0.28)
R&D intensity	-0.01	-0.04	0.05	0.03
	(0.06)	(0.03)	(0.04)	(0.02)
ICT	-0.06		0.20	
	(0.07)		(0.12)	
Net Imp.penCHN	-0.03***	-0.02***	-0.05	0.01
	(0.01)	(0.01)	(0.13)	(0.01)
Constant	0.06	-0.27***	-0.13	0.48***
	(0.10)	(0.02)	(0.13)	(0.09)
N	139	345	59	146
Country FEs	Yes	No	Yes	No
Country×period FEs	No	Yes	No	Yes
R^2	0.360	0.250	0.358	0.444

Notes: Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Estimates based on manufacturing NACE two-digit industries in columns (1) and (2) and non-manufacturing NACE one-digit industries in columns (3) and (4). Standard errors clustered at the country level. All variables are expressed in logs except Net Imp.pen^{CHN}. All Observations are weighted by beginning of period employment share in national employment. The dependent variable is the change in the log of employment. Petroleum and nuclear fuel industry is excluded from the analysis.

Column (1) and (3): Long differences from 1998 to 2007.

Column (2) and (4): Stacked differences from 1998 to 2007 and 2008 to 2010.

CONCLUSION

56. This paper has examined how employment polarization is associated with forces of technological change, offshoring and import competition in EU economies. We have shown that overall polarization consists of polarization within individual industries and the reallocation of labor away from industries with low polarization towards industries with high polarization. Both types of polarization were driven by the process of deindustrialization of developed economies. However, our results suggest that the three major forces that we consider in our analysis do not operate symmetrically for both types of polarization.

57. For manufacturing industries our evidence suggests that Chinese import competition and technological change through ICT adoption and R&D related process innovation are associated with high-paid employment polarization within individual manufacturing industries. Low-paid employment polarization was similarly affected by these different variables in Western European and Northern European countries, but in Southern and Central European countries the evidence suggests that there was a clear asymmetry in the statistical relation between the different forces and low- and high-paid polarization. This heterogeneity between countries would suggest that a uniform policy across all countries to counter polarization is unlikely to succeed and that a more country-specific approach must be considered in mitigating the effects of polarization on the labor market. Within-industry polarization in private industries other than manufacturing is strongly correlated with ICT-induced technological changes, while offshoring also had a role. Hence, polarization within industries is not uniformly driven by technology and globalization and depends on the characteristics of the industries.

58. To understand the polarization that has occurred as a result of the reallocation of employment from less polarized to more polarized industries, we have analyzed the relation between the three forces and employment growth in the industries. We found that Chinese net import penetration is strongly associated with employment losses in manufacturing industries, in accordance with the findings in the literature. Technological change is only weakly correlated with changes in employment in both manufacturing and non-manufacturing industries while offshoring is not relevant. These results show that polarization within industries and polarization due to employment reallocation are not fully symmetrically affected by the three forces in our analysis.

59. This paper offers several interesting pathways for future research and some policy prescriptions. First, we have demonstrated that different forces will affect labor markets in countries in distinct ways. To formulate a guideline for policy it is necessary to determine what characteristics of the labor market cause these divergent reactions. In this respect, this paper has shown that differences between countries in labor market institutions are not a sufficient explanation. However, future research will have to focus on these country-specific factors and their interaction with the forces of polarization to be able to provide relevant policy prescriptions. The widespread nature of polarization does suggest that there is a clear necessity for the use of policy instruments to smoothen the process of transition for workers. Second, we have chosen to study within- and between-industry polarization as two complementary processes. However, we have not addressed how both these processes are directly related. To understand how any outside force can lead to overall polarization, both types of polarization need to be considered in conjunction. Finally, throughout this paper we have considered the forces of technology and globalization as unrelated shocks influencing the polarization process. Nevertheless, all these factors are entangled so that a change in one factor directly affects the other. Disentangling these effects is clearly important in understanding the role of each force in polarization.

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ANNEX 1. SUMMARY STATISTICS AND GRAPHS

A.1 Offshoring

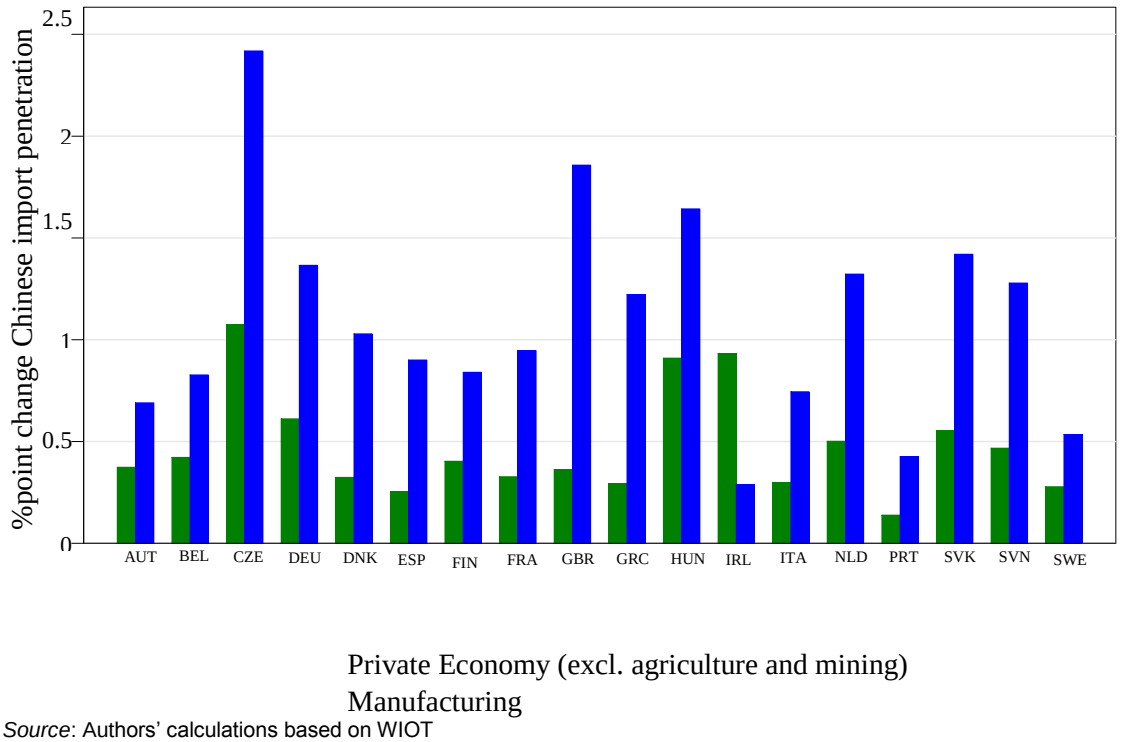
Table A1. ***TiVA* measure: Initial levels and evolution from 1995 to 2007 at the country level**

Country	TVA_{ict} in 1995	Change from 1995 to 2007
Ireland	38.5	4.59
Slovenia	32.3	4.45
Slovakia	31.9	14.85
Belgium	31.1	3.74
Czech Republic	30.5	11.92
Hungary	30.1	16.83
Portugal	27.4	5.77
Sweden	26.3	4.84
Finland	24.1	8.92
Netherlands	23.2	-3.99
Denmark	23.1	8.82
Austria	21.5	6.08
Spain	19.2	7.99
Great-Britain	18.3	0.47
France	17.3	7.04
Italy	17.2	7.31
Greece	16.3	7.71
Germany	14.9	8.77

Note: Authors' calculations based on OECD (2016)

A.2 Chinese import competition

Figure A1. **Change in Chinese import penetration 1995-2007 Within/between-sector decomposition of polarization**



Source: Authors' calculations based on WIOT

A.3 Summary statistics of regression samples

Table A2. **Summary statistics for variables included in within-sector polarization regressions**

	NACE two-digit Manufacturing sectors				
	Observations	Mean	Std.Dev.	Min.	Max.
top	1937	-1.01	0.71	-4.13	1.07
bottom	1928	-2.02	0.69	-4.48	-0.12
lnTiV A	1937	3.41	0.33	2.54	4.27
lnR&DIntensity	1937	0.55	1.52	-8.01	4.43
lnICT	1937	0.96	1.55	-2.87	7.36
lnImp.penCHN	1937	-0.41	1.33	-3.69	3.00
Union Density	1937	0.36	0.22	0.08	0.81
EPL	1937	0.28	0.80	-1.39	1.56
Adjusted Kaitz Index	1937	0.21	0.20	0	0.59

	NACE one-digit non-Manufacturing sectors				
	Observations	Mean	Std.Dev	Min	Max
top	809	-0.30	0.91	-2.79	2.22
bottom	809	-1.21	1.39	-4.23	2.99
TiV A	809	2.77	0.51	1.39	4.01
R&DIntensity	809	-1.55	1.59	-8.64	1.05
ln*ICT*	809	-1.78	1.52	-2.63	6.86
ln$Imp.pen^{CHN}$	809	-3.23	2.19	-16.86	1.09
Union Density	809	0.36	0.21	0.08	0.81
EPL	809	0.31	0.74	-1.39	1.558
Adjusted Kaitz Index	809	0.21	0.20	0	0.59

Notes: Summary statistics based on observations included in the regressions of column (5) of Table 5 (for broad NACE one-digit industries) and column (5) of Table 6 (for manufacturing NACE two-digit industries).

Table A3. **Summary statistics for variables included in between-industry reallocation regressions**

	NACE two-digit Manufacturing sectors				
	Observations	Mean	Std.Dev.	Min.	Max.
$\Delta \ln emp$	51	0.14	0.31	-0.58	0.86
$\Delta \ln TiV\ A$	51	0.14	0.20	-0.30	0.62
$\Delta \ln R\&DIntensity$	51	0.26	1.33	-2.19	3.33
$\Delta \ln ICT$	51	0.84	0.37	-0.22	1.75
$\Delta Imp.pen^{CHN}$	51	1.14	2.45	-11.30	6.49
$\Delta \text{Net Imp. pen}^{\text{CHN}}$	51	-0.03	0.30	-0.63	1.13

	NACE one-digit non-Manufacturing sectors				
	Observations	Mean	Std.Dev	Min	Max
$\Delta \ln emp$	145	-0.05	0.29	-1.01	0.53
$\Delta \ln TiV\ A$	145	0.11	0.15	-0.32	0.40
$\Delta \ln R\&DIntensity$	145	0.21	0.63	-2.78	2.45
$\Delta \ln ICT$	145	0.87	0.40	-0.47	2.07
$\Delta Imp.pen^{CHN}$	145	1.05	0.71	-1.24	2.51
$\Delta \text{Net Imp. pen}^{\text{CHN}}$	145	-1.57	3.57	-4.87	15.21

Note: Summary statistics based on observations included in the regressions of column (1) (for broad NACE one-digit industries) and column (3) (for manufacturing NACE two-digit industries) of Table 14.

ANNEX B. ADDITIONAL ROBUSTNESS CHECKS

B.1 Construction net import penetration measure

We construct two additional measures of trade exposure to China to account for the possible positive exposure some industries enjoy as a result of increased demand from the Chinese market. The export penetration measure is constructed in an analogous manner to our import penetration measure:

$$Exp.Pen_{ict}^{CHN} = \frac{EXP_{ict}^{CHN}}{Dom.abs_{ict}} \quad (5)$$

Where EXP_{ict}^{CHN} are the exports of industry *i* of country *c* to China at time *t* and $Dom.abs_{ict}$ is domestic absorption of the industry.

We also construct a Chinese net import penetration measure that combines the import and export penetration measures.

$$Net\ Imp.pen_{ict}^{CHN} = Imp.pen_{ict}^{CHN} - Exp.pen_{ict}^{CHN} \quad (6)$$

B.2 Construction downstream exposure measure

We use the methodology of Acemoglu et al. (2015) and Acemoglu et al. (2016) to construct the indirect exposure to downstream Chinese import penetration shocks. We start by aggregating some industries in the WIOD yearly input/output-tables so that the definition of the industries complies with the one used in our regressions. Next, we compute a coefficient $\widehat{a_{ij}}$ in the following manner:

$$\widehat{a_{ij}} = \frac{output_{i \to j}}{output_i} \quad (7)$$

These coefficients capture how important the sales from industry *i* to industry *j* are relative to the total output of industry *i*. As the increase in Chinese imports of industry *j* goods diminish demand for goods of the domestic industry *j*, domestic industry *j* will in turn reduce its demand of inputs from industry *i*. The greater is the importance of industry *j* in overall output of industry *i*, the more a shock of industry *j* is propagated to industry *i*. However, the reduction in demand for industry *j* goods might also trigger a decrease in demand for inputs from other industries to which industry *i* in turn provides inputs. Therefore, a reduction in demand for a downstream industry can trigger both direct and indirect reductions in demand for industry *i* output. We use the Leontief inverse element $\hat{a}_{ij}^{-1}$ to capture all direct and indirect effects on the output of industry *i* of a reduction in output of industry *j*. Next, we compute the indirect exposure of an industry *i* to a Chinese import penetration shock as follows:

$$Indirect\ Imp.pen_{t}^{CHN} = \sum_{j}^{J} \widehat{a_{ij,t-1}}^{-1}\ Imp.pen_{ict}^{CHN} \quad (8)$$

Where industry i is a domestic non-manufacturing industry and industries $j \in J$ are domestic manufacturing industries. The indirect exposure of a non-manufacturing industry is thus equal to the sum of the indirect exposures to Chinese import penetration of each individual manufacturing industry. We use the Leontief inverse element at moment $t-1$ as this has not been affected by the shock in year t.

Similarly, we construct an indirect net import penetration exposure measure by also taking increased export exposure into account.

$$Indirect\ Net\ Imp.pen_t^{CHN} = \sum_j^J \widehat{a_{ij,t-1}}^{-1}\, Imp.pen_{ict}^{CHN} - \sum_j^J \widehat{a_{ij,t-1}}^{-1}\, Exp.pen_{ict}^{CHN} \quad (9)$$

B.3 Additional results

We use an institutional dummy that is equal to one for those countries that satisfy three criteria: above median union density, above median employment protection and, finally, above median centralization of wage bargaining[26]. The relevant countries are Belgium, Finland, Italy and Slovenia. The institutional dummy is subsequently interacted with the globalization and technology forces. In this way, we wish to test whether those countries with strong labor market institutions show greater association of globalization and technological change with polarization.

In column (1) and (2) of Table B3 we re-estimate our sample using long differences over the period of 1998 to 2007. We start in 1998 to ensure that we have a maximum amount of crosssections included, since data in the early years of the sample contain many missing observations. The long differences are computed by subtracting the 1998 values from the 2007 values. In column (3) and (4) we do the same for the crisis period of 2008 to 2010. Finally, in columns (5) and (6) we use a stacked-regression approach similar to Acemoglu et al. (2016). The three stacked periods in our sample are from 1998 to 2003, 2004 to 2007 (accession of C-E countries to European Union) and 2008 to 2010 (crisis period and period with NACE rev 2 industry classification change). The results show that there is some proof that skill-biased technological change occurred in the case of the polarization of high-paid occupations, though the evidence is statistically weak. The crisis period is highly exceptional.

26. We use the variable level from the ICTWSS database of Visser (2015) which reports the predominant level at which wage bargaining takes place.

Table B1. **Explaining polarization using manufacturing sector data in the period 1996-2007: Differences between group of countries with strong institutions**

	Manufacturing		Non-manufacturing	
	(1)	(2)	(3)	(4)
	Top	Bottom	Top	Bottom
TiVA	0.20	-0.20	0.14	0.31**
	(0.12)	(0.17)	(0.18)	(0.11)
TiVA×Institutions	0.32	0.92***	0.10	0.02
	(0.34)	(0.28)	(0.27)	(0.25)
R&D intensity	0.07***	0.04	0.00	-0.01
	(0.01)	(0.06)	(0.02)	(0.01)
R&D intensity×Institutions	0.05	0.02	0.05*	0.02
	(0.03)	(0.08)	(0.02)	(0.02)
ICT	0.19***	0.16	0.15***	0.09
	(0.06)	(0.12)	(0.04)	(0.05)
ICT*Institutions	0.04	-0.40**	0.07	0.00
	(0.09)	(0.18)	(0.05)	(0.10)
Imp.pen^{CHN}	0.09**	0.13	0.01	0.01
	(0.03)	(0.09)	(0.01)	(0.01)
Imp.pen^{CHN}×Institutions	0.06	-0.04	-0.02	-0.01
	(0.06)	(0.10)	(0.02)	(0.02)
Union Density	0.65	2.45	-1.18	0.74
	(0.50)	(2.57)	(1.06)	(0.73)
EPL	0.06	-0.04	0.05	0.05
	(0.06)	(0.18)	(0.04)	(0.03)
Adjusted Kaitz index	-0.06	0.21	0.15	0.23
	(0.12)	(0.23)	(0.12)	(0.15)
Constant	-2.35***	-3.07**	-0.56	-2.06***
	(0.47)	(1.26)	(0.81)	(0.49)
N	1937	1932	809	809
Industry× country FEs	Yes	Yes	Yes	Yes
Ctry×Year FEs	No	No	No	No
R^2	0.934	0.799	0.977	0.985

Notes: Standard errors in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Estimates based on manufacturing sectors (NACE two digit) in columns (1) and (2) and non-manufacturing (NACE one digit) sectors excluding agriculture and mining in columns (3) and (4). Standard errors clustered at the country level. All variables are expressed in logs with the exception of the adjusted Kaitz index and labor union density. Observations are weighted with the share of employment in the sector relative to total national manufacturing employment. *Institutions* is a dummy that is equal to one for those countries with above median labor union density, above median employment protection legislation (EPL) and above median centralization of wage bargaining.

Table B2. **Explaining polarization using manufacturing sector data in the period 1996-2007: polarization computed with total hours**

	Manufacturing		Non-manufacturing	
	(1)	(2)	(3)	(4)
	Top hours	Bottom hours	Top hours	Bottom hours
TiVA	0.20	-0.09	0.29*	0.31***
	(0.13)	(0.18)	(0.17)	(0.10)
R&D intensity	0.06**	0.04	0.00	-0.02*
	(0.02)	(0.04)	(0.03)	(0.01)
ICT	0.21***	0.06	0.13***	0.07
	(0.04)	(0.08)	(0.03)	(0.04)
Imp.pen^{CHN}	0.10***	0.09	0.01	0.02*
	(0.03)	(0.06)	(0.01)	(0.01)
Union Density	1.11*	1.70	-0.77	0.99
	(0.62)	(2.21)	(0.83)	(0.63)
EPL	0.02	0.04	-0.02	0.10**
	(0.07)	(0.15)	(0.07)	(0.04)
Adjusted Kaitz Index	0.04	0.31	0.24*	0.29*
	(0.09)	(0.23)	(0.12)	(0.15)
Constant	2.44***	2.10*	3.93***	2.32***
	(0.58)	(1.13)	(0.63)	(0.39)
N	1937	1937	809	809
Industry× country FEs	Yes	Yes	Yes	Yes
Ctry×Year FEs	No	No	No	No
R^2	0.925	0.769	0.977	0.984

Notes: Standard errors in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Estimates based on manufacturing sectors (NACE two digit) in columns (1) and (2) and non-manufacturing sectors (NACE one digit) excluding agriculture and mining in columns (3) and (4). Standard errors clustered at the country level. All variables are expressed in logs with the exception of the adjusted Kaitz index and labor union density. Observations are weighted with the share of employment in the sector relative to total national manufacturing employment. Dependent variable computed by using total hours worked instead of employment.

Table B3. **Explaining polarization using manufacturing sector data in the period 1996-2010: Long and stacked differences**

	(1) top	(2) bottom	(3) top	(4) bottom	(5) top	(6) bottom
TiVA	-0.22	-0.15	-0.90**	0.54	0.08	-0.61
R&D intensity	0.11**	0.14**	0.01	-0.05	0.06**	-0.02
ICT	0.17	-0.07				
Imp.pen^{CHN}	0.03	0.10*	-0.04	0.19**	-0.02	0.00
TiVA×crisis					-0.85**	1.33*
R&D intensity×crisis					-0.03	-0.06
Imp.pen^{CHN}*crisis					0.00	0.24*
Union Density					0.92	-0.03
Adjusted Kaitz Index					-0.08	-1.07
EPL					-0.05	0.13
crisis					-0.03	-0.27***
Constant	0.61***	1.47***	0.12***	0.10***	0.36***	0.66***
N	145	145	161	161	541	541
Country FEs	Yes	Yes	Yes	Yes	Yes	Yes
*R*2	0.569	0.810	0.228	0.404	0.120	0.298

Notes: Standard errors in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Estimates based on manufacturing sectors (NACE two digit). Standard errors clustered at the country level. All variables are expressed in logs with the exception of the adjusted Kaitz index and labor union density. Observations are weighted with the share of employment in the sector relative to total national manufacturing employment.

Column (1) and (2): Period from 1998 to 2007

Column (3) and (4): Period from 2008 to 2010

Column (5) and (6): Three stacked periods from 1998 to 2003, from 2004 to 2007 and from 2008 to 2010

Table B4. **Explaining polarization using non-manufacturing sector data in the period 1996-2010: Long and stacked differences**

	(1) top	(2) bottom	(3) top	(4) bottom	(5) top	(6) bottom
TiVA	-0.47	0.21	0.44	0.29	-0.46	0.27
	(0.42)	(0.26)	(0.27)	(0.35)	(0.31)	(0.36)
R&D intensity	0.00	0.00	-0.01	-0.02	-0.02	0.01
	(0.03)	(0.05)	(0.02)	(0.02)	(0.02)	(0.02)
ICT	-0.23	-0.19				
	(0.18)	(0.20)				
Imp.pen^{CHN}	0.02	0.01	-0.02	0.03*	0.01	0.01
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Union Density					-1.63	2.47
					(2.01)	(2.73)
Adjusted Kaitz Index					0.11	-0.29
					(0.22)	(0.68)
EPL					0.00	-0.09
					(0.14)	(0.27)
Constant	0.94***	0.34	0.07***	-0.00	0.28***	0.18
	(0.21)	(0.19)	(0.03)	(0.03)	(0.08)	(0.11)
N	51	51	64	63	126	126
Country FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.605	0.325	0.641	0.298	0.206	0.109

Notes: Standard errors in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Estimates based on non-manufacturing sectors (NACE one digit), excluding agriculture and mining. Standard errors clustered at the country level. All variables are expressed in logs with the exception of the adjusted Kaitz index and labor union density. Observations are weighted with the share of employment in the sector relative to total national manufacturing employment.

Column (1) and (2): Period from 1998 to 2007

Column (3) and (4): Period from 2008 to 2010

Column (5) and (6): Three stacked periods from 1998 to 2003, from 2004 to 2007 and from 2008 to 2010

Table B5. **Explaining employment growth using non-manufacturing data in the period 1998-2010: Indirect exposure to Chinese import competition**

	Non-manufacturing industries	
	(1)	(2)
	$\Delta \ln emp$	$\Delta \ln emp$
TiVA	-0.10	-0.43
	(0.25)	(0.28)
R&D intensity	0.04	0.03
	(0.04)	(0.02)
ICT	0.20	
	(0.12)	
Net Imp.penCHN	-0.05	0.01
	(0.13)	(0.01)
Indirect net Imp.penCHN	0.11	0.00
	(0.18)	(0.10)
Constant	-0.12	0.49***
	(0.13)	(0.10)
N	59	146
Country FEs	Yes	No
Country×period FEs	No	Yes
R2	0.362	0.444

Notes: Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Estimates based on non-manufacturing NACE one-digit industries. Standard errors clustered at the country level. All variables are expressed in logs except Imp.pen^{CHN} and Net Imp.pen^{CHN}. All Observations are weighted by beginning of period employment share in national employment. The dependent variable is the change in the log of employment.

Column (1): Long differences from 1998 to 2007.

Column (2): Stacked differences from 1998 to 2007 and 2008 to 2010.