Endogenous competition exposure: China's rise and intra-firm adaptation

Benjamin Gampfer* Ingo Geishecker†

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Abstract

In this paper we analyse the manufacturing sector's capacity to mitigate the rising import competition from China. In our view, competition exposure is endogenous, i.e. influenced by firms' decisions which products are sold and what markets are served. We construct a counterfactual competition measure to assess the importance of different types of adaptation to increased competition: inter- and intra-industry reallocations, firm entry and exit, and product- and destination switching, among others. Combining Danish firm register data with transactional level trade statistics we are able to track product-level competition changes on the domestic as well as on each export market. Between 1997 and 2008 the exposure of Danish manufacturing to Chinese imports increased by 171 per cent but would have counterfactually increased by remarkable 240 per cent had the Danish economy not adapted. Firm exit and entry is the most important driver of sector-level adaptation but intra-firm mitigation through product-switching is disproportionately relevant as well. At the disaggregated firm level we find that larger firms are more successful in mitigating competitive pressure. Moreover, they are able to partly mitigate the adverse employment effects associated with increasing Chinese competition.

*Corresponding author, European University Viadrina, Faculty of Business and Economics, 15230 Frankfurt (Oder), Germany. E-Mail: gampfer@europa-uni.de.

†European University Viadrina, Faculty of Business and Economics, 15230 Frankfurt (Oder), Germany. E-Mail: geishecker@europa-uni.de.

1 Introduction

The unprecedented rise of exports from emerging economies has increased competition for firms from industrialised countries on their domestic as well as on their export markets. Of particular interest is the rise of China. The Chinese market reforms of the 1980s and 1990s unleashed huge productivity gains over the past decades and China's accession to the WTO in 2001 fostered integration to world trade. In the literature the rise in Chinese competition is perceived as an unforeseen exogenous shock for established economies with primarily adverse effects for their labour markets. Our paper revolves around the idea that competition exposure can be understood as something that is endogenous to the unit of observation. In the long run, the readily observable competition exposure may not only be shaped by the surge in imports but also by firms' decisions on what products to produce and which regional markets to serve. Our objective is to investigate the firms' capacity of adaptation to import competition and the labour market consequences of adaptation.

Previous research has already shown that higher exposure import competition is correlated with substantial reallocations of along extensive and intensive margins. Bernard, Jensen and Schott (2006) find a negative association between industry exposure to low-wage country import competition and US plant survival and sales growth. They were also the first to show that plants alter their product mix and switch to (disaggregated) industries that are less exposed to low-wage countries. In a more recent contribution utilising Mexican data Iacovone, Rauch and Winters (2013) not only track exposure to Chinese imports on the domestic market but also in the US, Mexico's most important export market. They confirm similar between and within plant reallocation effects in both markets. The study underlines also heterogeneous effects on within plant product sales shares. Products further away from the plants' core competence loose internal market share in response to the Chinese competition shock. Low-wage country imports are but only one driver of intra-industry and intra-firm reallocations. There is a growing strand of literature that investigates in general equilibrium models the determinants of within firm heterogeneity in

multiple-product and multiple-market firms (Bernard, Redding and Schott, 2010, 2011; Eckel and Neary, 2010; Mayer, Melitz and Ottaviano, 2014; Eckel, Iacovone, Javorcik and Neary, 2015).

Research on product and market portfolio reallocations is important as import competition from China or low-wage countries in general is associated with primarily adverse labour market outcomes. In this context our paper is related to a strand of literature influenced by Autor, Dorn and Hanson (2013). They construct a counterfactual competition exposure measure that holds the initial industry structure of US regions constant.[1] The long run variation depends on the exogenous change in industry-region specific Chinese imports. They find regions facing larger subsequent growth in Chinese imports to be associated with lower manufacturing employment, higher unemployment and lower wages. In a methodologically comparable study, Dauth, Findeisen and Suedekum (2014) show similar effects for Germany considering import competition from Eastern Europe and China. However, regions initially specialized also on exporting to China experienced net employment growth during the period of China's integration into the world market. Due to the construction of the exposure measure that holds the industry structure constant these results account for reallocations between industries but within industry reallocations are masked by that measure.[2]

In this context the contribution of our paper is threefold. First, we give a comprehensive account of the different dimensions of adaptation to increased Chinese competition. Drawing on the pioneering approach of Iacovone, Rauch and Winters (2013) we account for Chinese import competition at home as well as on *all* export markets. Therefore, we decompose changes of readily observable competition exposure into a counterfactual change

[1] The construction of the exposure measure by holding the initial industry or firm product-portfolio structure constant is also used by Bernard, Jensen and Schott (2006) and Iacovone, Rauch and Winters (2013).

[2] Other studies focus on outcomes at the individual worker level. Autor, Dorn, Hanson and Song (2014) find US workers initially working in industries with higher consecutive Chinese import penetration face lower cumulative earnings, show lower employment rates and are more likely to switch employers and industries. In a similar study Ashournia, Munch and Nguyen (2014) investigate effects of Chinese import competition for Danish individual workers. Unlike Autor, Dorn, Hanson and Song (2014) they measure competition exposure at the firm-level. They find a clear skill bias pattern of exposure to Chinese imports where the pressure on wages of low-skilled workers is larger than for high skilled workers.

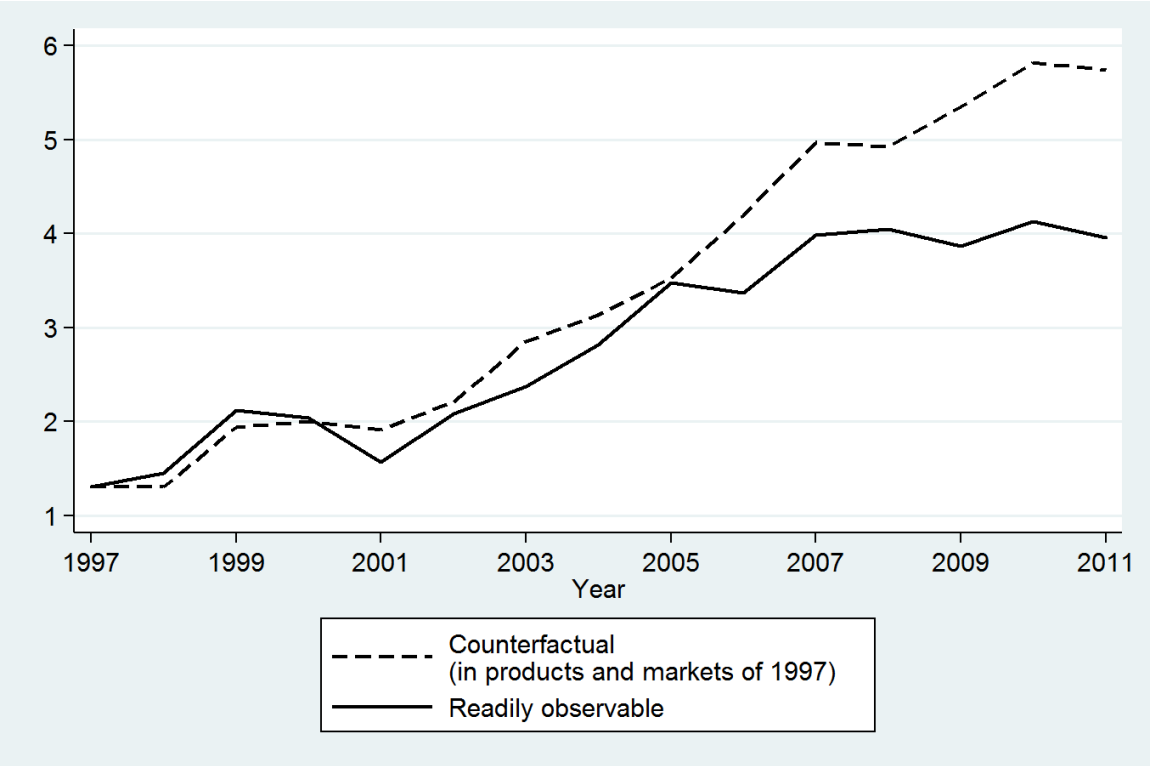
(holding the initial product and market portfolio constant) and several margins of adaptation. Those include firm exit and entry, product- and destination switching as well as reallocations along intensive margins between and within firms. Methodologically we build on the decomposition method developed by Olley and Pakes (1996) who explain different margins of aggregated productivity changes within an industry. Lewrick, Mohler and Weder (2014) show an expansion of this approach in a multi-industry framework. Second, we identify key drivers of firms' heterogeneous ability to mitigate Chinese competition. Third, we expand on Autor, Dorn and Hanson (2013) and Dauth, Findeisen and Suedekum (2014) by simultaneously assessing firm-level employment effects from changes in readily observable competition exposure as well as from intra-firm adaptation.

In our analysis we employ a detailed Danish register dataset. It combines firm- level characteristics with information on total product-level sales and product and market destination specific exports. Therefore, we are able to quantify competition exposure of firms and their products on the domestic and all export markets and to account for product and destination switching.

Overall Danish firms' aggregated exposure to Chinese imports has increased by 171 per cent between 1997 and 2008. However, our analysis reveals that if the Danish economy would not have adapted counterfactual competition exposure would have increased over the same period by 240 per cent. Figure 1 demonstrates the growing difference between readily observable competition exposure (solid line) and counterfactual competition exposure (dashed line) between 1997 and 2008. We find the readily observable or factual competition exposure is significantly shaped by firm entry and exit. Mitigation of competition exposure through product switching is also very relevant for surviving firms. Concerning the labour market, our analysis reveals that large firms are able to mitigate the adverse employment effects of increasing competition exposure by about 40 per cent if they successfully adapt to competition.

The next section provides details on the construction of the competition exposure measures and the decomposition method. Section 3 introduces the compilation of the dataset.

Figure 1: Exposure to Chinese imports for Danish manufacturing at home and all export markets, in per cent



Notes. Readily observable exposure to Chinese imports is calculated as the weighted average of China's share in overall imports for a given product and market. Each product market is weighted by its share in overall Danish manufacturing sales. Counterfactual exposure holds products and markets as well as their weights in Danish manufacturing constant from 1997 onwards and shows only how China's import share in these product markets changes until 2008.

Section 4 discusses the sector- and firm-level decomposition results. In section 5 we present common firm-level characteristics of successful mitigating firms as well as the mitigation effects on firm-level employment. Section 6 concludes.

2 Competition exposure and decomposition method

2.1 Endogenous competition and descriptive statistics

We examine changes in aggregate Chinese competition exposure of the Danish manufacturing sector between 1997 and 2008. As one upside of the detailed Danish data we can

construct sector-level competition exposure by aggregating from lower dimensions. Those are in descending hierarchical order the industry, firm, product and destination level. In contrast to previous research on import competition we are able to measure competition not only at the domestic market but also on each foreign export market.[3] For a small and open economy like Denmark this approach gives a more accurate picture of overall competition exposure.

To keep it simple we set up a definition of competition exposure for two major levels which are the manufacturing sector (with industry and firm level as sub-dimensions) and the firm level (with product and destination level as sub-dimensions).[4] We define sector level competition exposure in year t as Λ_t and firm level competition exposure of firm j, affiliated to industry k, as λ_{kjt}. Both measures are constructed from lower dimensions of aggregation weighted by the respective sales shares:

$$\Lambda_t = \sum_{k=1}^{K} \sum_{j=1}^{J_{kt}} \alpha_{kjt} \lambda_{kjt}, \qquad \lambda_{kjt} = \sum_{p=1}^{P_{kjt}} \sum_{d=1}^{D_{kjpt}} \omega_{kjpdt} C_{pdt}.$$

Hereby α_{kjt} denotes the firm's sales share in total manufacturing. J_{kt} denotes the number of firms in industry k and K the total number of industries which are constant over time. P_{kjt} denotes firm j's set of products in year t and D_{kjpt} the set of destinations in product p.[5] $\sum_{k=1}^{K}$, $\sum_{j=1}^{J_{kt}}$, $\sum_{p=1}^{P_{kjt}}$ and $\sum_{d=1}^{D_{kjpt}}$ are afterwards abbreviated as $\sum_k$, $\sum_j$, $\sum_p$ and $\sum_d$, respectively, to save space. Further, ω_{kjpdt} denotes the share of one unique product-destination pd in firm j's sales. If a product is not exported $D_{kjpt} = 1$ and represents the Danish home market only. Finally, C_{pdt} denotes China's market share in destination d among all imports

[3] The studies of Autor, Dorn and Hanson (2013), Autor, Dorn, Hanson and Song (2014), Dauth, Findeisen and Suedekum (2014) and Ashournia, Munch and Nguyen (2014) track import competition at different aggregation levels only at the home market. Other studies, e.g. interested in the impact of competition on firms' product mix as Mayer, Melitz and Ottaviano (2014), measure competition only at the export market destinations for each product.

[4] With this definition product switching always dominates and thus destination switching is understood as switching markets within continued products only.

[5] Although every firm level variable is uniquely identified with the index j we need the industry index k for the further steps of the decomposition.

of product p.[6] Constructing competition exposure in this way is key to our idea of adaptation: Competition exposure is not or only partly exogenous. Depending on the distinct decision to which destinations a product is shipped to and in the way how firms allocate sales within their product- and destination portfolio it is endogenous. To illustrate this, each product independent of the firm faces the same exposure to Chinese imports in each destination (C_{pdt}). However, competition exposure for the same product differs between firms as the destinations' sales share in the firms' portfolio and the destinations in general may vary between firms.[7] To utilise this variation in competition exposure within and between firms and its changes over time is one of the main ideas of our approach.

To give a first glimpse of the level and variation of the competition exposure measures Table 1 presents the aggregate sector level mean as well as mean and median values of competition exposure for 1997 and 2008 over $K = 17$ (partly aggregated) 2-digit NACE Rev. 2 industries. Aggregated exposure to Chinese imports in the Danish manufacturing sector increased from 1.45 per cent in 1997 to 3.95 per cent in 2008. This corresponds to a 1.71 fold increase in a period of rapid internationalisation of the Chinese economy.

Focussing first on competition exposure levels in 1997, most industries have median competition exposure close to zero or at least far below the manufacturing aggregate of 1.45 per cent. This indicates a high level of firm heterogeneity in competition exposure which has been already documented by Ashournia, Munch and Nguyen (2014) for the Danish home market. One big exception is the textile/apparel/leather industry where the median firm already has an exposure level of 7.26 per cent. This reflects the thorough impact of China in its prevailing comparative advantage industries at earlier stages of its internationalisation process. At the lower end of the distribution ranks, among others, food/drinks/tobacco where the median exposure is only 0.02 per cent. This is also no surprise as the ability to trade perishable products is limited by nature and hence the overlap of export destinations should be limited. These boundaries span the variation of competition

[6] The level of competition exposure can be expressed in per cent by multiplying C_{pdt} with one hundred.

[7] Product-level competition exposure is defined analogously to our two major levels as $\lambda_{kjpt} = (\sum_d (\omega_{kjpdt} / \Omega_{kjpt}) C_{pdt})$, where Ω_{kjpt} is the sales share of each product in the firms' portfolio.

Table 1: Competition exposure, sales weights and firm entry & exit by industry

	Competition exposure			Sales share	Firms	
	total (1)	mean (2)	median (3)	(%) (4)	number (5)	exit/entry rate (%) (6)
Panel A: Descriptive statistics 1997						
food/drinks/tobacco		0.35	0.02	30.5	256	56.3
textile/apparel/leather		7.03	7.26	2.9	175	71.4
wood		0.75	0.04	3.6	177	55.9
paper		0.46	0.21	2.9	84	61.9
print/publishing		0.07	0.03	2.6	226	76.1
refining/chemical/pharma		0.50	0.01	12.3	92	50.0
rubber/plastic		2.50	2.63	4.0	184	48.4
other minerals		0.44	0.00	4.5	138	42.0
basic metal		0.30	0.00	2.1	48	52.1
fabricated metal		1.65	0.58	6.7	440	51.4
computer/electronic/optical		3.49	0.86	3.9	126	58.7
electrical equipment		1.58	0.37	3.8	111	62.2
machinery n.e.c.		0.71	0.10	9.8	432	46.5
transportation		11.39	0.16	3.2	77	55.8
furniture		1.23	0.53	3.2	159	49.1
toys/sports goods/other		6.04	1.07	1.0	79	58.2
repair/installation		2.56	0.05	3.2	95	68.4
total	1.45	0.75	0.15	100.0	2,899	56.7
Panel B: Descriptive statistics 2008						
food/drinks/tobacco		0.63	0.11	31.5	222	49.6
textile/apparel/leather		15.54	17.14	1.6	82	39.0
wood		2.82	2.08	3.4	139	43.9
paper		4.22	3.57	2.0	60	46.7
print/publishing		1.51	0.59	1.7	121	55.4
refining/chemical/pharma		1.21	0.40	16.0	75	38.7
rubber/plastic		5.51	8.41	4.2	166	42.8
other minerals		2.30	0.91	4.7	133	39.9
basic metal		4.42	4.63	1.9	34	32.4
fabricated metal		7.11	7.14	7.3	462	53.7
computer/electronic/optical		9.18	5.60	3.8	107	51.4
electrical equipment		9.40	5.46	2.8	91	53.9
machinery n.e.c.		4.65	2.82	11.1	389	40.6
transportation		4.29	1.88	2.8	64	46.9
furniture		17.89	22.90	3.7	161	49.7
toys/sports/other		18.01	5.44	1.1	67	50.8
repair/ installation		8.07	6.13	0.6	49	38.8
total	3.95	4.65	4.01	100.0	2,422	45.5

Notes. The industry sales shares in this table might differ from sales shares published by Statistics Denmark. There are two reasons. First, we aggregate firm and industry sales shares from sales of goods per product according to the 6-digit HS-1992 classification which excludes sales of services which might be a substantial share in some manufacturer's portfolio. Secondly, for the purpose of variable construction we have to exclude some firms for which the data availability is limited. This process might also be unevenly distributed across industries. See Section 4 on details on the data.

exposure between industries.[8]

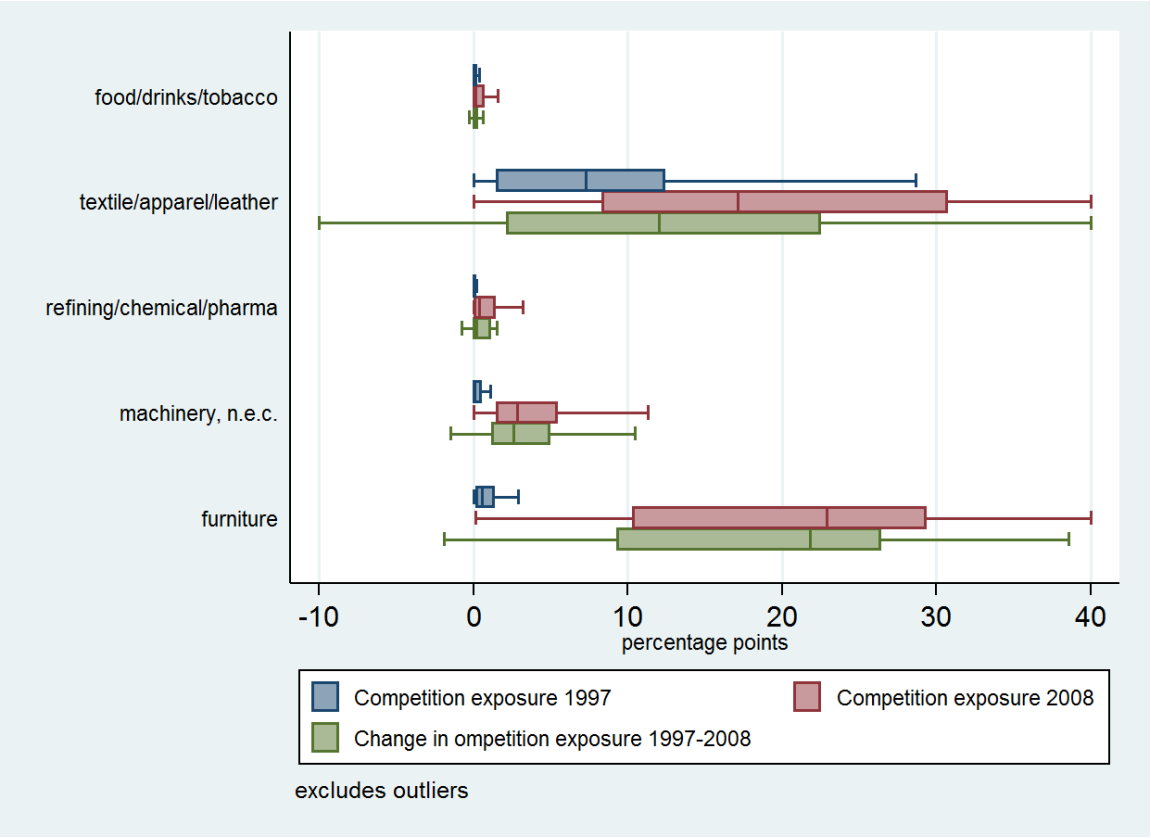
In 2008, competition exposure is with 3.95 per cent by far larger than in 1997. The median exposure in furniture is highest at 22.90 per cent. In half of the industries the median firm has a larger exposure than the manufacturing average, compared to 1997 where this was the case in only only two industries. This reflects the notion that the Chinese export supply diversified and comparative advantages shifted over time.

Comparing industry levels of median competition exposure with industry level firm exit/entry rates reveals interesting predictions. The correlation coefficient between column (3) and column (6) in Panel A is positive (0.32) indicating firm exit to be stronger in industries with high median competition exposure. In contrast, the correlation coefficient between both columns in Panel B is almost zero (0.02) indicating no relation between firm entry and median competition exposure. This finding already hints to a strong contribution of firm turnover, especially between industries, to sector wide adaptation to Chinese competition.

To round up the discussion of the competition exposure measures Figure 2 highlights the remarkably strong inter- and intra-industry heterogeneity in competition exposure and its change between 1997 and 2008 for some selected industries. The boxes contain the distribution of firm-level competition exposure between the 25th and 75th percentile. The whiskers (if not windsorized at -10 and +40) contain 1.5 times that inter-quartile difference. The upper box contains firm-level variation for 1997, the middle box for 2008 and the box at the bottom displays the variation in changing competition exposure for surviving firms, respectively. Especially for the highly exposed industries in 2008 the boxes show a very large dispersion of firm level competition exposure around the median. The median firm in furniture has an exposure of 22.90 per cent while it is only about half the value for

[8]One interesting stylized fact is the relatively high level of average competition exposure in the transportation industry which includes shipbuilding and related industries where Denmark is traditionally strong. These industries are also dominated by relatively large firms which explains the large discrepancy between mean and median value. We further observe for transportation a rather sharp decline in the average competition exposure in 2008. This may be due to an industry specific bias as shipbuilding projects are long-term and large in sales volume. Hence, Chinese and Danish project finalisation may not overlap in every year to the same extend leading to a rather volatile change in competition exposure.

Figure 2: Inter- and intra-industry variation in competition exposure and its change, 1997/2008, for selected industries



Notes. The boxplots exclude outside values and are winsorized at -10 and 40 percentage points.

the firm at the 25th percentile. In the textile/apparel/leather industry the difference in the exposure measure between 25th and 75th percentile is more than 20 percentage points. In comparison almost 50 per cent of the food/drinks/tobacco industry firms have an exposure measure close to zero. Considering changes in competition Figure 2 shows that many of the continuing firms increase their exposure by less than the industry average or even reduce it between 1997 and 2008. These firms are found in almost every industry, foremost in textile/apparel/leather. This finding underlines the importance of intra-firm adaptation to competition exposure which will be investigated by our *firm-level* decomposition.

2.2 Sector-level decomposition

The strategy to identify the different adaptation channels mentioned before is to decompose the change in competition exposure. This includes a counterfactual change, i.e. an exogenous competition trend, and an endogenous change reflecting industry- and firm-level adjustments to that trend. To quantify exogenous changes we construct a counterfactual competition measure pretending that no firm entry and exit and no inter or intra-industry reallocations take place. The counterfactual measure reflects changes in competition *net of adaptation*.

Our method of decomposition is based on a strand of literature investigating the source of aggregate productivity changes. Olley and Pakes (1996) construct aggregate industry productivity as the output or sales share weighted productivity average of single firms within the industry. To separate true productivity effects from mere output reallocations they split aggregate changes in pure intra-firm productivity changes and in changes of the output weights within the industry. Productivity levels and output shares of single firms are expressed as deviations from the industry average to address the "allocative efficiency" within the industry. If above average productivity levels are allocated to firms with above average output aggregate industry productivity rises. We rely on this method simply substituting productivity by competition exposure. However, we extend the scope for a multi-industry setting which was already put forward in the productivity literature by Lewrick, Mohler and Weder (2014). Our own methodological contribution is to additionally extend the application to the product and destination dimensions. This will be discussed in the next sub-section.

This section deals with the pure sector-level decomposition of competition exposure change. Firstly, we rewrite sector-level competition exposure as the aggregate of unweighted industry means and deviations of firm sales shares and firm level competition exposure from their unweighted industry means. Let $A_{kt} = \sum_j \alpha_{kjt}$ denote industry k's sales share in total manufacturing and α_{kjt}/A_{kt} a firm's sales share in its industry. Then we

can write sector level competition exposure as $\Lambda_t = \sum_k \sum_j A_{kt}(\overline{\alpha}_{kt} + \Delta\alpha_{kjt})(\overline{\lambda}_{kt} + \Delta\lambda_{kjt})$, where $\overline{\alpha}_{kt} = 1/J_{kt}$ is the unweighted firm sales share in each industry and $\overline{\lambda}_{kt} = \sum_j \lambda_{kjt}/J_{kt}$ denotes the unweighted industry level competition exposure. $\Delta\alpha_{kjt} = (\alpha_{kjt}/A_{kt}) - \overline{\alpha}_{kt}$ denotes the deviation of a firm's sales share within its industry from the unweighted industry mean and $\Delta\lambda_{kjt} = \lambda_{kjt} - \overline{\lambda}_{kt}$ denotes a firm's deviation from the unweighted industry competition exposure mean. Expanding this transformation of sector level competition exposure and cancelling terms that are equal to zero yields

$$\Lambda_t = \sum_k A_{kt}\overline{\lambda}_{kt} + \sum_k \sum_j A_{kt}\Delta\alpha_{kjt}\Delta\lambda_{kjt}. \tag{1}$$

Aggregate manufacturing competition exposure is now decomposed into two parts. The first term on the right hand side of Eq. (1) weighs the unweighted industry mean competition exposure by the industry sales shares in total manufacturing. It can be interpreted as a measure of the overall competition exposure level in t. The second term captures the covariance of deviations of firm sales share and firm level competition exposure from the industry mean. It is positive whenever in sum firms with above (below) industry average sales share have above (below) industry average competition exposure. If the second term is negative the allocation of sales shares to firm level competition exposure is more efficient than a uniform distribution would suggest.

Our primary interest is the contribution of both terms to the change in competition exposure over time. To make clear counterfactual statements we want to separate changes in industry or firm level competition exposure from changes in industry or firm-level sales share weights. When taking the difference between end of period year t and beginning of period year 0, we therefore add and directly subtract the counterfactual terms $\sum_k A_{k0}\overline{\lambda}_{kt}$

and $\sum_k \sum_j A_{k0} \Delta \alpha_{kjt} \Delta \lambda_{kjt}$. Rearranging respectively yields

$$\begin{aligned} \Lambda_t - \Lambda_0 &= \sum_k (A_{kt} - A_{k0}) \left[\overline{\lambda}_{kt} + \left(\sum_j \Delta \alpha_{kjt} \Delta \lambda_{kjt} \right) \right] \\ &+ \sum_k A_{k0} (\overline{\lambda}_{kt} - \overline{\lambda}_{k0}) + \sum_k \sum_j A_{k0} (\Delta \alpha_{kjt} \Delta \lambda_{kjt} - \Delta \alpha_{kj0} \Delta \lambda_{kj0}). \end{aligned} \tag{2}$$

The first term on the right hand side now measures changes in industry level sales shares given the value in square brackets. The square bracket can be simplified to industry level competition exposure Λ_{kt} if we insert for $\Delta \alpha_{kjt}$ and $\Delta \lambda_{kjt}$ and expand the bracket.[9] The second term on the right hand side of Eq. (2) captures the changes in unweighted average industry competition exposure levels, holding industry sales shares at their initial level. Finally, the third term represents the changes in allocative efficiency.

Through exit and entry of firms the industry structure, however, changes over time. This makes it worth to differentiate changes in competition exposure levels and allocative efficiency for exiting, continuing and entering firms. Let the set of entering firms be indicated by $E \in J_{kt}$, exiting firms by $X \in J_{k0}$ and continuing firms by $C \in J_{kt}$. Within the first term of the right hand side of Eq. (2) we can now separate changes in industry sales shares that are due to changes in sales shares of surviving firms[10] and due to changes in sales shares that are caused by unbalanced inter-industry firm exit and entry.[11] Considering the second term we can define unweighted industry average competition exposure for each set of firms in year t as $\overline{\lambda}^{\gamma}_{kt} = \sum_{j \in \gamma} \lambda_{kjt} / J^{\gamma}_{kt}$, with $\gamma \in \{E, X, C\}$ and J^{γ}_{kt} denoting the respective number of firms in the set γ. To split the third term on the right hand side of Eq. (2) we just take the sums over the distinct firm sets in each year. As continuing firms are observed both in t and in 0 we finally split this term in changes due to relative industry sales shares and due to relative industry competition exposure - holding the respective other part con-

[9] $[\overline{\lambda}_{kt} + \left(\sum_j \Delta \alpha_{kjt} \Delta \lambda_{kjt}\right)] = \overline{\lambda}_{kt} + ((\alpha_{kjt}/A_{kt}) - \overline{\alpha}_{kt})(\lambda_{kjt} - \overline{\lambda}_{kt})$. Multiplying out the right hand side and eliminating terms equal to zero yields $(\alpha_{kjt}/A_{kt})\lambda_{kjt}$ which is equal to Λ_{kt}. This measure is the industry equivalent to the sector level competition exposure.

[10] $\sum_k \sum_{j \in C} \left(\alpha_{kjt} - \alpha_{kj0}\right)$.

[11] $\sum_k (\sum_{j \in E} \alpha_{kjt} - \sum_{j \in X} \alpha_{kj0})$.

stant - by adding and subtracting $\sum_k \sum_{j\in C} A_{k0}\Delta\alpha_{kj0}\Delta\lambda_{kjt}$.[12] Put together, the competition exposure decomposition for the sector-level yields

$$
\begin{aligned}
\Lambda_t - \Lambda_0 \;=\; & \underbrace{\sum_k A_{k0}(\overline{\lambda}^{C}_{kt} - \overline{\lambda}^{C}_{k0})}_{\text{I}} \\
& + \underbrace{\sum_k \sum_{j\in C} \left(\alpha_{kjt} - \alpha_{kj0}\right)\Delta\Lambda_{kt}}_{\text{II}a} + \underbrace{\sum_k \Big(\sum_{j\in E} \alpha_{kjt} - \sum_{j\in X} \alpha_{kj0}\Big)\Delta\Lambda_{kt}}_{\text{II}b} \\
& + \underbrace{\sum_k \sum_{j\in C} A_{k0}\Delta\alpha_{kj0}(\Delta\lambda_{kjt} - \Delta\lambda_{kj0})}_{\text{III}} + \underbrace{\sum_k \sum_{j\in C} A_{k0}\Delta\lambda_{kjt}(\Delta\alpha_{kjt} - \Delta\alpha_{kj0})}_{\text{IV}} \\
& + \underbrace{\sum_k A_{k0}\delta^{E}_{kt}(\overline{\lambda}^{E}_{kt} - \overline{\lambda}^{C}_{kt}) - \sum_k A_{k0}\delta^{X}_{k0}(\overline{\lambda}^{X}_{k0} - \overline{\lambda}^{C}_{k0})}_{\text{V}a} \\
& + \underbrace{\sum_k \sum_{j\in E} A_{k0}\Delta\alpha_{kjt}\Delta\lambda_{kjt} - \sum_k \sum_{j\in X} A_{k0}\Delta\alpha_{kj0}\Delta\lambda_{kj0}}_{\text{V}b},
\end{aligned}
\tag{3}
$$

where $\Delta\Lambda_{kt} = \Lambda_{kt} - \overline{\Lambda}_t$ is the equivalent of $\Delta\lambda_{kjt}$ at the industry level.[13] $\delta^{E}_{kt} = J^{E}_{kt}/J_{kt}$ and $\delta^{X}_{k0} = J^{X}_{k0}/J_{k0}$ denote the share of all entering and exiting firms, respectively, in their periods.[14]

The components on the right hand side of Eq. (3) need further explanation. The first term (I) is the *industry-level* or *counterfactual competition effect*. It is the change in average unweighted industry competition exposure for continuing firms at constant industry sales shares comprising the trend of the whole manufacturing sector. The role of this term is to capture changes in *counterfactual* competition exposure at the sector level. If competition exposure is increasing and the counterfactual competition effect is larger than the factual change in competition exposure, the manufacturing sector mitigates competition exposure through at least one of the other allocation or level effects (II*a* - V*b*).

The terms II*a* and II*b* together comprise the *inter-industry allocation effect*. It is ex-

[12] For the detailed steps refer to the Appendix.

[13] Note that $\overline{\Lambda}_t = \sum_k \Lambda_{kt}/K$ and $\sum_k (A_{kt} - A_{k0})\Lambda_{kt} = \sum_k (A_{kt} - A_{k0})\Delta\Lambda_{kt}$, as $\sum_k (A_{kt} - A_{k0})\overline{\Lambda}_t = \overline{\Lambda}_t \sum_k (A_{kt} - A_{k0}) = 0$.

[14] For derivation of the decomposition details refer to the Appendix.

pected to be negative if in sum industries with above (below) average competition exposure lose (gain) market share. Especially in a long run perspective these terms should definitely be negative as simple theories of comparative advantage suggest the specialisation of economies in distinct industries in the wake of international competition. In our context it is more likely to see a pronounced increase of competition exposure in labour intensive and relatively low-tech industries and sales share reallocations away from those firms in Denmark. Term II*a* specifically captures the contribution of continuing firms and II*b* the contribution of unbalanced inter-industry firm exit and entry to the inter-industry reallocation effect.

The third row of Eq. (3) deals with intra-industry allocations. Term III summarizes the change in relative firm level competition exposure while holding its relative firm sales share within the industry and the industry's sales share constant. It captures all effects coming from distinct intra-firm decisions affecting relative firm level competition exposure such as product or destination switching or smooth adjustments like sales share reallocations between continued product-destinations. In the next sub-section we uncover those effects by decomposing this term in a similar way. In contrast, term IV holds the firms' relative industry competition exposure and their industry's sales share constant and measures the contribution of *intra-industry* sales share reallocations. The term is negative if continuing firms with above industry average competition exposure lose relative market share in their industry and vice versa.

The last components of the decomposition capture intra-industry competition exposure level effects (V*a*) and intra-industry allocation effects (V*b*) through firm exit and entry. V*a* directly describes the adaptation to the trend development. It compares the unweighted average competition exposure level for entering and exiting firms with those of continuing firms rescaled by the respective weights in their period. V*b* gives information on changes in the allocative efficiency between sales shares and competition exposure among old and new firms within their industries. Together with term II*b* these effects contain the total

adaptation contribution induced by firm entry and exit.[15]

2.3 Firm-level decomposition

Considering our main interest, the scope and sources of intra-firm adaptation, we proceed by decomposing the firm-level competition effect (III) partly in analogy to the sector-level before. First we need to isolate changes in actual competition exposure from the firm level competition effect. Therefore, $\Delta\lambda_{kjt}$ is split again into $\lambda_{kjt} - \overline{\lambda}_{kt}$. Let firm level competition exposure, as described before, be defined as $\lambda_{kjt} = \sum_p \sum_d \omega_{kjpdt} C_{pdt}$, where ω_{kjpdt} denotes the share of product-destinations pd firm j's sales and C_{pdt} China's import share of product p in destination d. Analogously to the industry sales shares, let $\Omega_{kjpt} = \sum_p \omega_{kjpdt}$ denote product p's sales share in total firm sales and $\omega_{kjpdt}/\Omega_{kjpt}$ a destination's sales share within the product p. Then we can rewrite firm level competition exposure as $\lambda_{kjt} = \sum_p \sum_d \Omega_{kjpt}(\overline{\omega}_{kjpt} + \Delta\omega_{kjpdt})(\overline{C}_{kjpt} + \Delta C_{kjpdt})$, where $\overline{\omega}_{kjpt} = 1/D_{kjpt}$ is the unweighted destination sales share in each product and $\overline{C}_{kjpt} = \sum_d C_{kjpdt}/D_{kjpt}$ denotes the unweighted product competition exposure. $\Delta\omega_{kjpdt} = (\omega_{kjpdt}/\Omega_{kjpt}) - \overline{\omega}_{kjpt}$ denotes a destination's deviation in product sales share from the unweighted product mean and $\Delta C_{kjpdt} = C_{kjpdt} - \overline{C}_{kjpt}$ denotes the destinations' deviation from the unweighted product mean in competition exposure. Expanding this equation yields

$$\lambda_{kjt} = \sum_p \Omega_{kjpt}\overline{C}_{kjpt} + \sum_p \sum_d \Omega_{kjpt}\Delta\omega_{kjpdt}\Delta C_{kjpdt}. \tag{4}$$

Firm level competition exposure is now decomposed into two parts. The first term on the right hand side of Eq. (4) weights the unweighted mean of product level competition exposure by the products' sales shares within the firm. It can be interpreted as a measure of the general level of competition exposure of the firm. The second term captures the covariance of deviations of destination sales share and destination level competition exposure from

[15] As we track manufacturing sector firms only, entry and exit is not necessarily to be understood as complete new firms or complete shut-down. To some degree firms may switch to or from the services (or primary) sector.

the product mean. It is positive whenever in sum destinations with above (below) average sales share account for above (below) average competition exposure. If the second term is negative the allocation of sales shares to destination level competition exposure is more efficient than a uniform distribution would suggest.

In the next step we split the sum for the sets of continued products ($Pc \in P_{kjt}$), dropped products ($Pd \in P_{kj0}$) and added products ($Pa \in P_{kjt}$).[16] Considering product adding and dropping first, the allocation effect is analogously constructed as for firm entry/exit. $\sum_{p \in Pa} \sum_d \Omega_{kjpt} \Delta \omega_{kjpdt} \Delta C_{kjpdt}$ captures reallocation effects for added products and $\sum_{p \in Pd} \sum_d \Omega_{kjpt} \Delta \omega_{kjpdt} \Delta C_{kjpdt}$ reallocation effects for dropped products. For the product switching level effect the level terms for added ($\sum_{Pa} \Omega_{kjpt} \overline{C}_{kjpt}$) and dropped products ($\sum_{Pd} \Omega_{kjp0} \overline{C}_{kjp0}$) again need a comparison term for continued products in their respective period. However, we lack such a term as the continued products itself are decomposed into destination switching and reallocation effects. To keep the exposition of the product switching level effect simple we refer to the unweighted industry level of competition exposure ($\overline{\lambda}_{kt}$) as the comparison term which is left over from splitting up the firm-level competition effect ($\lambda_{kjt} - \overline{\lambda}_{kt}$). The downside of this approach is of course that unweighted industry average competition exposure is not necessarily positively correlated with unweighted average competition exposure for continued products. This can eventually distort the product switching level effect for single firms. The upside of this approach is twofold. First, it keeps the decomposition simple as no residual terms are left. Secondly, even if there was a simple possibility to technically implement continued products' unweighted competition exposure as a comparison term, it could not be used as the data is missing for a couple of firms. Between 1997 and 2008 roughly one fifth of the product switching firms in the sample churn their entire portfolio such that there are no continued products. For those firms the best comparison group for dropped and added products is the industry's level in the respective year.

Within the set of continued products we further differentiate the set of added destina-

[16] For the details refer to the Appendix.

tions ($Da \in D_{kjpt}$), the set of dropped destinations ($Dd \in D_{kjp0}$) and the set of continued destinations ($Dc \in D_{kjpt}$). Within the continued destinations group we construct one term for the extensive destination switching margin, one term for between product reallocations and one term for product level effects. We also adjust the latter for deviations from the unweighted industry mean such that all terms from the split of $\Delta\lambda_{kjt}$ are utilised. The total firm level competition effect (III) is then decomposed to

$$\sum_k \sum_{j\in C} A_{k0}\Delta\alpha_{kj0}(\Delta\lambda_{kjt} - \Delta\lambda_{kj0}) = \tag{5}$$

$$= \Bigg[\sum_k \sum_{j\in C} A_{k0}\Delta\alpha_{kj0} \Bigg(\underbrace{\sum_{p\in Pc} \Omega_{kjp0}\left((\overline{C}^{Dc}_{kjpt} - \overline{\lambda}_{kt}) - (\overline{C}^{Dc}_{kjp0} - \overline{\lambda}_{k0})\right)}_{\text{VI}}$$

$$+ \underbrace{\sum_{p\in Pc} (\Omega_{kjpt} - \Omega_{kjp0})(\lambda_{kjpt} - \overline{\lambda}_{kt})}_{\text{VII}}$$

$$+ \underbrace{\sum_{p\in Pa} \Omega_{kjpt}(\overline{C}_{kjpt} - \overline{\lambda}_{kt}) - \sum_{p\in Pd} \Omega_{kjp0}(\overline{C}_{kjp0} - \overline{\lambda}_{k0})}_{\text{VIII}a}$$

$$+ \underbrace{\sum_{p\in Pa}\sum_{d} \Omega_{kjpt}\Delta\omega_{kjpdt}\Delta C_{kjpdt} - \sum_{p\in Pd}\sum_{d} \Omega_{kjp0}\Delta\omega_{kjpd0}\Delta C_{kjpd0}}_{\text{VIII}b}$$

$$+ \underbrace{\sum_{p\in Pc}\sum_{d\in Dc} \Omega_{kjp0}\Delta\omega_{kjp0}(\Delta C_{kjpdt} - \Delta C_{kjpd0})}_{\text{IX}a} + \underbrace{\sum_{p\in Pc}\sum_{d\in Dc} \Omega_{kjp0}\Delta C_{kjpt}(\Delta\omega_{kjpdt} - \Delta\omega_{kjpd0})}_{\text{IX}b}$$

$$+ \underbrace{\sum_{p\in Pc} \Omega_{kjp0}\delta^{Da}_{kjpt}(\overline{C}^{Da}_{kjpt} - \overline{C}^{Dc}_{kjpt}) - \sum_{p\in Pc} \Omega_{kjp0}\delta^{Dd}_{kjp0}(\overline{C}^{Dd}_{kjpd0} - \overline{C}^{Dc}_{kjpd0})}_{\text{X}a}$$

$$+ \underbrace{\sum_{p\in Pc}\sum_{d\in Da} \Omega_{kjp0}\Delta\omega_{kjpdt}\Delta C_{kjpdt} - \sum_{p\in Pc}\sum_{d\in Dd} \Omega_{kjp0}\Delta\omega_{kjp0}\Delta C_{kjpd0}}_{\text{X}b} \Bigg) \Bigg] .$$

Analogous to the sector-level decomposition and $\overline{\lambda}^{\gamma}_{kt}$ in Eq. (3), $\overline{C}^{\sigma}_{kjpt} = \sum_{d\in\sigma} C_{kjpdt}/D^{\sigma}_{kjpt}$, is the unweighted average competition exposure per destination set with $\sigma \in \{Da, Dd, Dc\}$

and D^{σ}_{kjpt} denoting the respective number of destinations in the set σ. $\delta^{Da}_{kjpt} = D^{Da}_{kjpt}/D_{kjpt}$ and $\delta^{Dd}_{kjp0} = D^{Dd}_{kjp0}/D_{kjp0}$ denote the share of all added and dropped destinations, respectively, in their periods.

Again the terms deserve further explanation. Term VI is similar to term I from the sector level decomposition and therefore the label *product level competition effect* is suitable. It captures the change in unweighted competition exposure for continued products holding constant their respective sales share within the firm. However, as a residual from splitting up $\Delta\lambda_{kjt}$ we correct this change for the respective deviation from the level of the unweighted industry mean competition exposure. So, in comparison to the industry level competition effect (I) which is constructed from *average* competition exposures of continuing firms (and especially their continuing products), term VI captures the possibility that continued products of surviving firms can deviate from that general trend.

Term VII, similarly to term II*a*, contains *intra-firm* sales share reallocations between continued products given the products' competition exposure deviation from the unweighted industry average. The next two rows of Eq. (5) contain effects from product switching. VIII*a* captures changes in competition exposure levels through product adding and dropping, again compared to the the unweighted industry mean. VIII*b* comprises the reallocations within the set of added and dropped products. Terms IX*a* and IX*b* are similar to III and IV of the sector-level decomposition. IX*a* comprises the change in the relative exogenous competition exposure within the set of continued destinations holding the sets' share within the product and the sales share of the product within the firm constant. Term IX*b* vice versa accounts for reallocations within the set of continued destinations. Finally, the terms X*a* and X*b* contain level and allocation effects stemming from destination switching.

As the preliminary analysis shows many of these terms tend to be close to zero as the sector-level sales shares on lower levels (e.g. sales share of all dropped destinations) become ever smaller. Hence, in the analysis we will concentrate on more aggregated effects. Adaptation through product switching will comprise VIII*a* + VIII*b* = VIII, aggre-

gated destination switching comprises Xa + Xb = X, and reallocation effects for continued product-destinations comprise VII + IXb. The level effects for continued products (VI) and continued destinations (IXa) together account for the intra-firm counterfactual competition effect analogously to the term I in the sector level decomposition. Together they describe the counterfactual level change of competition exposure net of any adaptations through product- or destination switching.

3 Data

The data employed in this analysis is compiled from several different sources. The General Enterprise Statistic contains general accounting information (e.g. value added, full time equivalent employment or capital assets) for the universe of firms with economic activity in Denmark. We limit the sample to manufacturing firms using the Danish industry classification of 2007 which corresponds on the 2-digit level to the common European NACE Rev. 2 classification.[17] We further concentrate on the years between 1997 and 2008 since this is the largest time span with coherent data. We are interested in long run changes in the decomposition of competition and thus take 1997 as the start year 0 and 2008 as the end year t.

The Foreign Trade Statistics Register comprises 8-digit Combined Nomenclature (CN) transactional level data for trade with EU-countries (Intrastat) and non-EU-countries (Extrastat). In 2008 the threshold value for reporting inner European trade by product and partner country is 5,200,000 Danish crowns (DKK) total export value. Reporting extra-EU trade by product and partner country is obligatory above a value of 7,500 DKK. We aggregate the transaction data to the 6-digit product level of the UN Harmonized System (HS-6) as our Chinese import share variables will be on the same aggregation level.

The third dataset contains total firm sales per product at the 8-digit CN level which

[17] We merge some industries to have a sufficient number of firms for each group. By 2-digit number we merge 10, 11 and 12 to *food/tobacco*, 13, 14 and 15 to *textile/apparel/leather*, 19, 20 and 21 to *refining/chemical/pharma*, 28 and 29 to *transportation*.

we also aggregate to the HS-6 level. However, only firms with at least ten employees and, moreover, only shipments from plants with their main activity belonging to the manufacturing sector are surveyed here. To partly correct for this shortcoming we restrict our sample to firms with at least ten full time employees. All three datasets are combined by a unique firm identifier.

Unfortunately, we have no direct source that contains sales by product in the firms' domestic market destination Denmark. As an approximation we compute domestic sales by product as the residual between total sales and exports. With the incompleteness of the before mentioned total sales per product database domestic sales for some products will be negative. Should the total firm sales share from products with negative domestic sales cross 50% of total sales we exclude the firm from the sample in order to not distort our initial sales weights.

To construct the competition measure C_{pdt} we use the BACI dataset which is based on UN-Comtrade data and contains country-level bilateral imports of HS-6 level products. Within our time horizon the HS-classification was reformed twice (2002, 2007). To avoid incorrectly identifying product switching through mere changes in the product code we convert all HS-6 product codes to the 1992 classification of the HS using the official UN correspondence tables. Finally, we merge the share of Chinese imports in total imports per product destination from the BACI dataset to each Danish firm-product-destination. The final sample contains 2,899 firms and 35,336 distinct firm-product-destination observations in 1997 and 2,422 firms and 43,556 distinct firm-product-destination observations in 2008. In our firm-level analysis we can draw on the information of 1,287 surviving firms that are active in both 1997 and 2008.

4 Decomposition results

This section discusses the result of the integrated decompositions of Eqs. (3) and (5). This allows a direct comparison of the contribution of e.g. product-switching and firm entry

and exit to sector level adaptation. Table 2 presents the results of decomposing the change in Danish manufacturing competition exposure between 1997 and 2008. Panel A contains the total factual and counterfactual change in competition. Panel B presents the detailed margins of adaptation. The Roman number below each cell indicates the exact effects from Eqs. (3) and (5).

Panel A presents the change in aggregated competition exposure in relative terms. The total increase in factual manufacturing competition exposure amounts to 171 per cent. This corresponds to weighted average of the Chinese import share of 1.45 per cent in 1997 and 3.95 per cent in 2008 (see Table 1). To measure the total counterfactual increase we sum up I+VI+IX*a*, where (I) accounts for the general increase net of any sector-level adaptations and (VI) and (IX*a*) as, also quantitatively, small adjustments of the aggregated firm-level increase net of intra-firm adaptations. The counterfactual increase in competition exposure - net of any adaptation - is with 240 per cent much larger than the factual increase. The absolute adaptation or reduction of competition exposure increase is 69 percentage points. In absolute terms these numbers are already impressive, but meaningful is an interpretation in relative terms: Without adaptation the competition exposure increase in Denmark would have been by about two fifth larger (i.e. 69/171). This is a substantial reduction and reflects the importance of an endogenous competition exposure measure.

Panel B presents in detail where the 69 percentage points (ppt.) of adaptation are generated both in absolute and in relative terms. In the previous section we already discussed that within industries with high median competition exposure the firm exit rates where also higher. Based on Eq. (3) we can introduce more rigour to that analysis. Inter-industry market share reallocation induced by firm-entry and exit account for 16 percentage points or almost one quarter of sector wide adaptation in relative terms. This reflects the notion that firms tend to exit from highly exposed industries and enter in less exposed. Intra-industry level and allocation effects of firm entry and exit account for 31 percentage points or almost one half of total adaptation. The latter effect mirrors larger competition exposure levels for exiting than of continuing firms within industries and smaller levels for entering

Table 2: Factual and counterfactual competition exposure change and adaptation, 1997-2008

Panel A: Change in competition exposure					
Factual change ($\Lambda_t - \Lambda_0$)		171	%		
Counterfactual change (I+VI+IX*a*)		240	%		
Adaptation		69	percentage points (p.p.)		
Panel B: Adaptation decomposition					
		absolute			share (%)
Firm Exit/Entry					
Inter-industry market share reallocations (II*b*)		16	*p.p.*		23
Intra-industry level & allocation effects (V*a*+V*b*)		31	*p.p.*		46
Surviving firms					
Inter-industry market share reallocations (II*a*)		5	*p.p.*		7
Intra-industry market share reallocations (IV)		12	*p.p.*		17
Intra-firm adaptation (III)		5	*p.p.*		7
thereof:	Product-switching (VIII*a*+VIII*b*)		6	*p.p.*	9
	Destination-switching (X*a*+X*b*)		0	*p.p.*	0
	Reallocations between continued products & destinations (VII+IX*b*)		-1	*p.p.*	-2
Total adaptation		69	*p.p.*		

Notes. Panel A: The factual change of 171 % corresponds to a competition exposure level of 1.45 per cent in 1997 and 3.95 per cent in 2008 (see Table 1). For the counterfactual change and the decomposed margins in Panel B Roman numbers in brackets assign each margin's corresponding terms from Eqs. (3) and (5). Positive absolute values or per cent shares indicate a reduction of factual competition change along the respective margin of adaptation. Negative values indicate an increase in factual competition change.

firms. Moreover, summarized in this term, we find that larger allocation of sales shares to the less exposed entering firms is a crucial driver of that margin. Together all firm exit or entry induced adaptations account for 69 per cent (23+46) of total adaptation.

On the other hand, 31 per cent of sector-level adaptation is generated by surviving firms which is somewhat less than predicted by the weight of this set of firms in the decomposition. 7 per cent of sector wide adaptation is due to inter-industry sales share reallocations induced by surviving firms. This is less than the contribution of firm entry and exit to inter-industry reallocations but nevertheless a reshuffling that reduces factual competition increase. Industries with above average competition exposure tend to decline over time

while industries with below average competition exposure grow. Moreover, to observe a substantial degree of intra-industry reallocations in the wake of international competition is also what could be expected (Melitz, 2003). We observe that about 17 per cent of total adaptation is due to larger relative sales growth of firms with below average competition exposure.

The bottom part of Table 2 summarizes in detail the contribution of intra-firm adaptation. This margin accounts for about 7 per cent of sector-level adaptation. The decomposition of the intra-firm adaptation effects shows that it is entirely driven by product-switching. Through product-switching alone the contribution of the intra-firm adaptation effect would have been even larger (about 9 per cent). However, destination-switching has on aggregate no effect and more importantly through the remaining margin, the sales share reallocations between continued products and destinations, factual competition change is even slightly increased. Nevertheless, these numbers first of all indicate that continuing firms on aggregate mitigate their competitive pressure by internal reallocations, foremost along the extensive product margin. On the other hand, intra-firm adaptation seems to play a minor role in sector-wide adaptation.

Is the small share bad news for the capacity to adapt to competition for surviving firms? First of all, whether the contribution to adaptation of different margins is small or large crucially depends on the weight each margin's product and destination set is attached with in the decomposition. Table 3 contains the annual sales shares of different firm, product and destination sets used in the decomposition. All firms that are to exit the market until 2008 account for an aggregated sales share of 57.0 per cent in 1997. 51.3 per cent of the sector wide sales in 2008 is generate by firms that were entering the market since 1997. Both numbers roughly correspond to the entry and exit rates reported in Table 1. So, considering the weight of entering and exiting firms of more than 50 per cent, a substantial contribution to sector wide adaptation is justified but the contribution share of 69 per cent is clearly larger than expected. Of course, this implies that the contribution to adaptation of surviving firms is with about 31 per cent lower than what their sales share would predict. But what

Table 3: Sales share by firm, product & destination set, in per cent

	1997		2008	
Exiting/Entering firms	57.0		51.3	
Continuing firms	43.0		48.7	
Dropped/added products		5.1		6.9
Continued products		37.9		41.8
Dropped/added destinations		1.8		2.6
Continued destinations		36.1		39.2

Notes. The set of continuing firms contains the set of dropped/added products in each year. The set of continuing products contains the set of dropped/added destinations and the set of continuing destinations in each year

about the distribution of decomposition weights and adaptation contribution within the set of surviving firms? According to Table 3, 36.1 per cent of the sector wide sales in 1997 is generated by continued products in their continued destinations. In contrast, only 5.1 per cent of sales in 1997 is generated by products that are to be dropped until 2008. New products of surviving firms account for a sector wide sales share of 6.9 per cent in 2008. Hence, the contribution to sector wide adaptation of product-switching of about 9 per cent is also way above the weight that switched products are attached in the decomposition. In fact, in relation to the weight of the relevant product-destination set the adaptation contribution of product-switching is of similar importance as firm entry and exit. This underlines the prominent role of intra-firm adaptation for mitigating competitive pressure from China.

Finally, there is one argument why the contribution of intra-firm adaptation in Table 2 describes rather a lower bound for this mitigating impact. On the one hand, the objective of the decomposition is to clearly separate intra-firm effects from between firm reallocation effects. On the other hand, the method is agnostic about the drivers behind the decomposed margins. The 12 percentage points mitigation of the intra-industry market share reallocation effect (IV), for instance, is to be interpreted that firms with below industry average competition exposure in 2008 gained relative market share between 1997 and 2008 within their industry, or vice versa. What the margin does not reveal is whether the relatively lower competition exposure level is the consequence of intra-firm mitigation or just a rela-

tively less exposed constant product-destination portfolio. Furthermore, it is possible that gains in relative market share are the consequence of successful intra-firm adaptation to competition or just pure luck to expand in a niche of the industry which is covered from competition exposure over a longer time horizon. Hence, there is scope for indirect effects of intra-firm mitigation that are covered by the intra- and also the inter-industry reallocation effects of surviving firms.

5 Firm level analysis

5.1 Mitigation and firm characteristics

The decomposition of aggregate factual competition change underlined the importance of intra-firm competition mitigation for sector wide adaptation. This section leaves now the aggregate perspective and considers only the sample of surviving firms in search for drivers of firm-level competition mitigation and its consequences. In the mathematics of our decomposition from the previous section change in factual competition exposure splits into the sum of counterfactual and mitigation. Hence, mitigation is actually negative defined, i.e. the mitigation variable would become more negative if more competition is mitigated. We multiply mitigation by minus 1 to obtain a more straight forward positive definition, such that a larger mitigation variable means a larger reduction of competition exposure.

To get a first impression of the firm-level distribution of factual and counterfactual competition change as well as firm level adaptation Table 4 contains some descriptive statistics. In the sample of all surviving firms factual and counterfactual show a very similar distribution with competition increase of 5.63 and 5.50 percentage points, respectively. Whereas firm at the 10th percentile has almost zero factual competition change the firm at the 90th percentile faces an increase of 15.73 percentage points. This shows again the large degree of heterogeneity already discusses before. Remember aggregate competition exposure increased from 1.45 percentage points to 3.95 between 1997 and 2008. Our focus rests now

Table 4: Descriptive statistics of firm level factual and counterfactual competition change and mitigation 1997 to 2008, in percentage points

	Mean	Std. Dev.	p10	p25	Median	p75	p90
All surviving firms							
Factual	5.63	8.16	0.01	0.52	3.23	7.45	15.73
Counterfactual	5.50	7.97	0.04	0.58	3.23	6.71	15.07
Mitigation	-0.13	4.44	-2.74	-0.52	0.00	0.48	2.45
Large surviving firms							
Factual	5.27	6.89	0.03	0.59	3.10	6.74	14.50
Counterfactual	5.37	7.00	0.04	0.74	3.23	6.60	13.54
Mitigation	0.10	3.94	-2.44	-0.79	0.00	0.85	2.98

Notes. $N = 1,287$ for the sample of all surviving firms. $N = 330$ for the sample of large surviving firms. Large surviving firms are those above the 75th percentile of the employment distribution within their 2-digit NACE industry.

on the distribution of firm level mitigation. It reveals a remarkable difference to aggregate or sales weighted intra-firm adaptation. As the mean counterfactual increase is slightly below the mean factual competition increase the average firm actually increases its factual competition change by about 0.13 percentage points. The reason for this disparity shows up if the sample is reduced to the very large firms within one industry. Here the average firm mitigates about 0.10 percentage points of its factual competition increase. The large firms are attached with more weight in the decomposition and so the aggregate contribution turns positive, i.e. a mitigation effect. An analysis of the percentiles shows the median firm does not mitigate or adapt at all while about half of the firms mitigate their factual competition change about one half of the firms does actually increase its factual competition change by internal adaptation.

To put more rigour on this investigation we correlate the volume of firm-level mitigation with some ordinary enterprise characteristics. We estimate several forms of the equation

$$\begin{aligned} MITIGATION_j^{1997-2008} &= \beta_0 + \beta_1 COUNTERFACTUAL_j^{1997-2008} \\ &\quad + \beta_2 CE_j^{1997} + \beta_3 X_j^{1997} + \phi_l + \varepsilon_j, \end{aligned} \tag{6}$$

where *MITIGATION* denotes the total firm level mitigation volume between 1997 and 2008. Here, we do not separate our different margins (product and destination switching

and the reallocations) from the decomposition to capture all relevant aspects of competition mitigation. Hence, $MITIGATION$ is the sum over the terms VII, VIIIa, VIIIb, IXb, Xa and Xb from Eq. (5). The remaining two terms (VI and IXa) capture our firm-level counterfactual change in competition exposure represented above as $COUNTERFACTUAL$. It is reasonable to control for the counterfactual change due to the strong heterogeneity in factual competition change. A firm with no change in factual competition could be the result of a constant Chinese import ratio or the result of mitigation. So, $COUNTERFACTUAL$ controls for the scope of mitigation a firm can achieve. Additionally, we include the initial level of competition exposure CE.[18] As competition exposure is bounded at zero firms with higher initial competition exposure also have a higher scope for mitigation.[19] Both variables controlling for the scope of mitigation should of course be positively correlated with mitigation. X denotes initial firm level characteristics such as size by employment or sales, capital intensity or labour productivity. ϕ_l represents a fixed effect for affiliation in one of l 3-digit NACE Rev. 2 industries to account for industry specific time trends between 1997 and 2008. Unlike our decomposition industry level k at 2-digits, here we account for the strong intra-industry heterogeneity at the 2-digit level. The standard error denoted by ε is robust to l 3-digit industry clusters to capture error correlation due to time independent industry level shocks or measurement errors. β_0 denotes the constant.

Table 5 shows the correlations described by Eq. (6). As expected, the two variables controlling for the scope of mitigation are positive and also highly significant. As mitigation, counterfactual change and initial competition exposure are measured in percentage points the interpretation is straight forward. In all specifications from column (1) to (8) a one percentage point increase in counterfactual competition change is ceteris paribus related to a 0.21 percentage point increase in mitigation. A one percentage point higher initial level of competition exposure is ceteris paribus associated with a 0.12 to 0.13 percentage point increase in mitigation. Among the firm characteristics describing a capacity to mitigate

[18] The initial competition exposure level CE is equivalent to λ_{kj0} from the decomposition.

[19] Mitigation is of course also possible if there is no counterfactual change given the firm is initially exposed to Chinese imports.

Table 5: Mitigation and firm characteristics
Dependent variable: Firm-level MITIGATION of competition exposure (in % pts)

	(1)	(2)	(3)	(4)	(5)	(6)	(8)
COUNTERFACTUAL$^{1997-2008}$	0.2076***	0.2086***	0.2095***	0.2076***	0.2081***	0.2093***	0.2088***
	(0.0295)	(0.0295)	(0.0298)	(0.0295)	(0.0296)	(0.0294)	(0.0296)
Competition Exposure^{1997}	0.1230***	0.1298***	0.1285***	0.1265***	0.1247***	0.1285***	0.1316***
	(0.0369)	(0.0366)	(0.0374)	(0.0375)	(0.0371)	(0.0368)	(0.0364)
Log Employment^{1997}	0.2353**						
	(0.0952)						
Log Average Hourly Wage^{1997}		1.4476					
		(0.9274)					
Log Labour Productivity^{1997}			0.5295				
			(0.3246)				
Log Capital Intensity^{1997}				0.0634			
				(0.2407)			
Log Sales^{1997}					0.2627**		
					(0.1013)		
High Skilled Employment Share^{1997}						0.0283*	
						(0.0157)	
Low Skilled Employment Share^{1997}							-0.0142
							(0.0093)
Constant	-1.2382***	-7.6728	-7.2688*	-1.1563	-4.9628***	-0.6685***	0.1732
	(0.3864)	(4.6782)	(4.2415)	(3.0211)	(1.7992)	(0.1881)	(0.3676)
Observations	1,287	1,287	1,287	1,287	1,287	1,287	1,287
R-squared (within)	0.08	0.08	0.08	0.08	0.08	0.08	0.08
No. of industry FE	80	80	80	80	80	80	80

Notes. Robust standard errors in parentheses are clustered at 3-digit industry level. The dependent variable mitigation is measured in percentage points. Hence, for all control variables measured in logs the coefficients can be interpreted as the induced change in mitigation in percentage points if the control variable ceteris paribus doubles; i.e. for instance every doubling of firm level employment is associated with a 0.24 percentage point increase of mitigation. Counterfactual and Competition exposure of 1997 as well as the employment shares by skill group are measured in percentage points.
*** statistically significant at 1 percent level,
** statistically significant at 5 percent level,
* statistically significant at 10 percent level.

competition exposure we find foremost that absolute size in terms of employment or sales seems to matter. Both coefficients are statistically significant at the 5 percent level. Large firms are ceteris paribus associated with a higher mitigation of competition exposure. In our level-log specification every 100 per cent increase or doubling of employment would relate to a 0.24 percentage point increase in mitigation. The firm at the 90th percentile has 12 times as many employees as the firm at the 10th percentile. Hence, the larger firm would have a $0.24 \times 12 = 2.88$ percentage points larger mitigation than the smaller firm. Assuming both firm face the average factual increase of 5.63 percentage points, a larger firm size has also an economically significant impact on mitigation.

Apart from absolute firm size only a higher skill intensity has a significant positive impact on the capacity to mitigate. However, the coefficient is very small and of no economic

significance.[20] Yet another statement of Table 5 is the relative large share of the mitigation variable which remains unexplained. The R-squared for variation within our 3-digit industries is only about 0.08. Thus, firm heterogeneity in mitigation is extraordinarily large and only partly related to conventional firm level characteristics.

5.2 Competition increase, mitigation and employment change

Earlier research on the impact of import competition has strongly focused on labour market or individual wage effects (Autor, Dorn and Hanson, 2013; Dauth, Findeisen and Suedekum, 2014; Ashournia, Munch and Nguyen, 2014). The general procedure hereby is to relate a specific labour market outcome with an import penetration variable. In this way Autor, Dorn and Hanson (2013) find that a larger increase in US regional import penetration from China is associated with a sharper reduction in the regional manufacturing employment ratio. Their regional import penetration ratio is constructed as the change in industry-level US imports from China weighted by the region's initial share of employment in that industry. Except from the more granular level of measurement at the product-destination level, our concept of counterfactual competition exposure with initial sales weights is similar to this approach. Now, what does the concept of mitigation tell us here?

Our decomposition approach allows to split the counterfactual change into the factual competition change and mitigation. With the mitigation or adaptation part we are able to control for changes in the initial industry or product-destination portfolio structure. Thus, we can give reference to the endogeneity of competition exposure. Using again the sample of the surviving firms we fit models of the form

$$\begin{aligned} \Delta Y_j^{1997-2008} &= \theta_0 + \theta_1 MITIGATION_j^{1997-2008} + \theta_2 FACTUAL_j^{1997-2008} \\ &\quad + \mathbf{Z}_j' \theta_3 + \phi_l + u_j, \end{aligned} \tag{7}$$

[20] A one percentage point increase in the share of high skilled workers is associated with a 0.03 percentage point increase in mitigation.

where ΔY represents the long run change of a firm-level variable of interest, e.g. employment, over the period 1997 to 2008. θ_0 denotes a constant and $MITIGATION$ as before the firm level adaptation through product and destination switching as well as market share reallocations. $FACTUAL$ denotes the true change in competition exposure between start and end of the period.[21] The vector $\mathbf{Z}$ contains further control variables such as initial competition exposure (CE^{1997}) or the initial level of Y. ϕ_l represents a fixed effect for affiliation in one of l 3-digit NACE Rev.2 industries to account for industry specific time trends between 1997 and 2008. The standard error denoted by u is robust to l 3-digit industry clusters to capture error correlation due to time independent industry level shocks or measurement errors. θ_0 denotes the constant.

Concerning the interpretation of the marginal effects of the variables from Eq. (7) caution is needed. θ_1 can be directly interpreted as the marginal effect of $MITIGATION$. $FACTUAL$, however, comprises the competition change including the portfolio reallocations of the firm, i.e including $MITIGATION$. With the positive definition of mitigation linear dependence between our decomposition variables is *MITIGATION* = *COUNTERFACTUAL* - *FACTUAL*, which we substitute for in Eq. (7). The marginal effect of factual competition increase is therefore

$$\begin{aligned} \frac{\partial \Delta Y}{\partial FACTUAL} &= \frac{\partial(\theta_0 + \theta_1(COUNTERFACTUAL - FACTUAL) + \theta_2 FACTUAL + \mathbf{Z}'\theta_3)}{\partial FACTUAL} \quad (8) \\ &= -\theta_1 + \theta_2. \end{aligned}$$

This substitution is furthermore reasonable as it reveals the following necessity: The marginal effect of $COUNTERFACTUAL$ in the above formula is also equal to θ_1 as the marginal effect of $MITIGATION$. In a ceteris paribus analysis, i.e. given two firms have the same change in $FACTUAL$, a change in $COUNTERFACTUAL$ must imply an equal change in $MITIGATION$ to obtain the same change in $FACTUAL$ due to the linear dependence in the variables. With this setting we are able to analyse the joint impact of increasing competition exposure and firm-level adaptation on any labour market or firm-

[21] $FACTUAL$ is equivalent to $\lambda_{kjt} - \lambda_{kj0}$ from the decomposition notation.

level outcome ΔY.

Table 6 contains the marginal effects of a Eq. (7) regression where the dependent variable is the Log change in firm-level employment between 1997 and 2008. The columns contain different (sub-)samples of our 1,287 surviving firms. Column (1) utilises the full set of surviving firms. In this specification an increase in factual competition exposure at the firm-level between 1997 and 2008 is related to a statistical significant reduction in firm-level employment in the same time horizon. The coefficient -0.62 is the marginal effect of *FACTUAL* multiplied with 100. In our log-level specification the marginal effects can be interpreted as semi-elasticities. This implies a 1 percentage point increase in firm-level factual competition exposure is, ceteris paribus, predicted to reduce firm-level employment by 0.62 per cent. For a firm with the average competition increase of 5.63 percentage points employment would be reduced by 3.49 per cent. The firm at the 90th percentile of competition change distribution with an increase of 15.73 percentage points would cut down employment by about 9.75 per cent in our in-sample prediction. So far these findings highlight the pressure on manufacturing workers within firms as it was already documented before (Autor et al., 2014). The new idea is to allow firms to alter their product and destination mix in order to improve their competitive position and potentially to safe jobs. However, as Column (1) reveals in our full sample we find no statistically significant impact of firm level mitigation on employment change.

Regarding our results on mitigation and firm characteristics (see Table 5) we should account for the fact that the capacity to mitigate is not uniformly distributed among firms but larger firms do slightly better. To keep the interpretation of marginal effects straight forward we simply split our sample of surviving firm into different size subsets. For the regressions in columns (2) to (4) firms are divided into sub-samples according to their employment size within 2-digit industries.[22] Large firms are those above the 75th percentile and small firms below the 25th percentile of the employment distribution within indus-

[22]We split by firm size at the 2-digit industry level as some 3-digit industries are very small such that a split by percentiles is not meaningful.

Table 6: Employment effects of Mitigation and Factual competition change
Dependent variable: Log change in firm level employment between 1997 and 2008

Marginal effects	All firms	I. Sub-samples$^{(a)}$ by firm size			II. Sub-samples$^{(b)}$ by firm size		
		Large	Medium	Small	Large	Medium	Small
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FACTUAL$^{1997-2008}$	-0.62**	-1.88***	-0.46	0.31	-1.25*	-0.67**	0.21
	(0.28)	(0.48)	(0.56)	(0.39)	(0.46)	(0.49)	(0.38)
MITIGATION$^{1997-2008}$	0.34	1.44***	-0.18	-0.49	0.99**	0.08	-0.29
	(0.28)	(0.70)	(0.43)	(0.34)	(0.76)	(0.32)	(0.37)
Observations	1,287	330	615	342	325	603	359
R-squared (within)	0.07	0.05	0.01	0.00	0.04	0.02	0.00

Notes. Robust standard errors in parentheses are clustered at 3-digit industry level. The numbers above show marginal effects of Mitigation and Factual competition change multiplied by 100. Hence, the marginal effects can be interpreted as semi-elasticities reflecting the percent change in employment by a one percentage point change in Factual competition change or Mitigation. All regressions include a constant, Log Employment^{1997}, Competition Exposure^{1997} and industry fixed effects at the 3-digit NACE Rev. 2 level as further control variables.
$^{(a)}$ In columns (2) to (4) firms are divided according to their employment size within 2-digit industries. Large firms are those above the 75th percentile, small firms below the 25th percentile of the employment distribution and medium sized firms in between.
$^{(b)}$ In columns (5) to (7) firms are divided by their general or manufacturing wide employment size . Large firms are those above the 75th percentile, small firms below the 25th percentile of the employment distribution and medium sized firms in between.
*** statistically significant at 1 percent level,
** statistically significant at 5 percent level,
* statistically significant at 10 percent level.

tries. Medium sized firms are in between. Within the sample of large firms in Column (2) the effect of factual competition change is still negative and significant. In absolute terms it is even larger than for all surviving firms . Moreover, we are now able to detect a statistical significant positive mitigation effect for large firms. Referencing to our descriptive statistics we can also interpret the economic significance. A large firm with the average factual competition increase for large firm of 5.27 percentage points has, ceteris paribus, a predicted job reduction of 9.90 per cent (5.27×1.88). On the one hand, if this firm is only an average mitigating firm it reduces 0.10 percentage points of competition exposure which would translate into a counteracting employment growth of mere 0.14 per cent (0.10×1.44). On the other hand, if this firm is at the 90th percentile of the mitigation distribution of large firms it reduces competition exposure by 2.98 percentage points which would translate into a relatively substantial counteracting employment growth of 4.29 per cent (2.98×1.44). Hence, among large firms the best mitigators can save about half of the jobs that would be lost to an average competition increase.

Columns (2) and (3) show that basically the whole competition and mitigation effects

are generated by the large firms within an industry as the marginal effects for medium and small sized firms remain insignificant. For comparison in the columns (5) to (7) firms are divided according to their relative size by employment in general or at the sector level. The thresholds are again at 75th and 25th percentile. For large firms the effects remain qualitatively the same except that they are less significant. In return, medium sized firms now also face a significant negative employment impact of a factual competition increase.

6 Concluding remarks

In this paper we construct endogenous measures of manufacturing- and firm-level adaptation to competition. Holding the initial industry structure constant and tracking only the exogenous increase of Chinese imports for surviving firms' continued products and destinations yields a counterfactual measure of competition exposure. The readily observable, factual, exposure to Chinese imports by product and destination increased for Danish manufacturing by 171 per cent between 1997 and 2008. However, it would have had increased counterfactually - i.e. net of any adaptations - by remarkable 240 per cent, had the initial industry structure not changed. The decomposition of adaptation shows that about 69 per cent of this differential is due to firm entry and exit and thereby induced inter- and intra-industry reallocations. About 9 per cent of the sector wide mitigation stems from pure intra-firm product-switching of surviving firms. However, this share in adaptation is much larger than the weight of switched products in the decomposition. Accordingly, competition exposure from China is indeed endogenous and significantly shaped by intra-firm reallocations.

Our analysis also reveals a high degree of firm heterogeneity in adaptation to competition exposure. While on aggregate the contribution foremost through product-switching, is quite substantial the unweighted average of firm-level adaptation is slightly negative even though close to zero. Also the median firm neither increases competition exposure nor does it mitigate through internal reallocations. Correlating the firm-level mitigation with

some enterprise characteristics we find that mitigation increases with firm size. Comparing the firm at the 90th employment percentile with the firm at the 10th employment percentile the larger had its factual competition exposure in reduced by additional 2.88 percentage points. However, a large share of the variance in firm-level mitigation remains unexplained by conventional covariates.

Concerning change of firm-level employment we find a substantial adverse effect of Chinese import penetration for all firms. Within a sub-sample of large firms, the successfully mitigating firms can prevent about 40 to 50 per cent of their competition induced job losses thanks to adaptation. Disregarding this endogenous adaptation distorts the true extent of growing competition from China.

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Appendix

Sector-level decomposition

The second term on the right hand side of Eq. (2) measures the change in unweighted industry average competition exposure. It can be split into into the components for continuing, exiting and entering firms used in Eq. (3) by the following steps

$$\begin{aligned}\sum_k A_{k0}(\overline{\lambda}_{kt}-\overline{\lambda}_{k0}) &= \sum_k A_{k0}\delta^E_{kt}\overline{\lambda}^E_{kt}+\sum_k A_{k0}(1-\delta^E_{kt})\overline{\lambda}^C_{kt} \\ &- \sum_k A_{k0}\delta^X_{kt0}\overline{\lambda}^X_{k0}-\sum_k A_{k0}(1-\delta^X_{k0})\overline{\lambda}^C_{k0} \\ &= \sum_k A_{k0}(\overline{\lambda}^C_{kt}-\overline{\lambda}^C_{k0})+\sum_k A_{k0}\delta^E_{kt}(\overline{\lambda}^E_{kt}-\overline{\lambda}^C_{kt})-\sum_k A_{k0}\delta^X_{k0}(\overline{\lambda}^X_{k0}-\overline{\lambda}^C_{k0}),\end{aligned} \tag{9}$$

where δ^E_{kt} and δ^X_{k0} denote the share of all entering and exiting firms, respectively, in their periods. $\overline{\lambda}^E_{kt}$, $\overline{\lambda}^X_{k0}$ and $\overline{\lambda}^C_{kt}$ denote the respective industry averages of competition exposure of entering, exiting and continuing firms, respectively. The three terms derived by Eq. (9) are the industry average competition exposure changed for continuing firms, second, the mean differential between entering and continuing firms and third, the mean differential between exiting and continuing firms holding constant the industry sales shares. The third term on the right hand side of Eq. (2) is also split for entering, exiting and continuing firms. To obtain one term where we can hold the sales shares constant and one where the competition exposure level is constant we add and subtract $\sum_k\sum_{j\in C}A_{k0}\Delta\alpha_{kj0}\Delta\lambda_{kjt}$. Rearranging terms yields

$$\begin{aligned}\sum_k\sum_j A_{k0}(\Delta\alpha_{kjt}\Delta\lambda_{kjt}-\Delta\alpha_{kj0}\Delta\lambda_{kj0}) &= \sum_k\sum_{j\in C}A_{k0}\Delta\alpha_{kj0}(\Delta\lambda_{kjt}-\Delta\lambda_{kj0}) \\ &+ \sum_k\sum_{j\in C}A_{k0}\Delta\lambda_{kjt}(\Delta\alpha_{kjt}-\Delta\alpha_{kj0}) \\ &+ \sum_k\sum_{j\in E}A_{k0}\Delta\alpha_{kjt}\Delta\lambda_{kjt}-\sum_k\sum_{j\in X}A_{k0}\Delta\alpha_{kj0}\Delta\lambda_{kj0}.\end{aligned} \tag{10}$$

The first term measures for surviving firms changes in firm level competition exposure

holding firm and industry sales shares constant. The second term measures for surviving firms the contribution of changes in firm sales shares holding industry sales shares and firm level competition exposure constant. The remaining terms add the contribution of entering and exiting firms, respectively.

Firm-level decomposition

We first split $\Delta\lambda_{kjt}$ into $\lambda_{kjt} - \overline{\lambda}_{kt}$. Then the firm-level competition effect (III) is decomposed according to Eq. (4) and split into the distinct sums for continued and discontinued products. For clarity we leave out the firm and industry level summation and just split up $\Delta\lambda_{kjt} - \Delta\lambda_{kj0}$.

$$
\begin{aligned}
\Delta\lambda_{kjt} - \Delta\lambda_{kj0} \;=\; & \sum_{p\in Pc} \Omega_{kjpt}\overline{C}_{kjpt} + \sum_{p\in Pc}\sum_{d} \Omega_{kjpt}\Delta\omega_{kjpdt}\Delta C_{kjpdt} \\
& - \sum_{p\in Pc} \Omega_{kjp0}\overline{C}_{kjp0} - \sum_{p\in Pc}\sum_{d} \Omega_{kjp0}\Delta\omega_{kjpd0}\Delta C_{kjpd0} \\
& + \sum_{p\in Pa} \Omega_{kjpt}\overline{C}_{kjpt} + \sum_{p\in Pa}\sum_{d} \Omega_{kjpt}\Delta\omega_{kjpdt}\Delta C_{kjpdt} \\
& - \sum_{p\in Pd} \Omega_{kjp0}\overline{C}_{kjp0} - \sum_{p\in Pd}\sum_{d} \Omega_{kjp0}\Delta\omega_{kjpd0}\Delta C_{kjpd0} \\
& - \sum_{p\in Pc} \Omega_{kjpt}\overline{\lambda}_{kt} - \sum_{p\in Pa} \Omega_{kjpt}\overline{\lambda}_{kt} + \sum_{p\in Pc} \Omega_{kjp0}\overline{\lambda}_{k0} + \sum_{p\in Pd} \Omega_{kjp0}\overline{\lambda}_{k0}.
\end{aligned}
\tag{11}
$$

The first four rows of Eq. (11) are in direct analogy to Eq. (4). The terms in the last row of Eq. (11) refer to the unweighted industry average competition exposure which is here also split into continued and discontinued product sets according to the set's sales share. Rearranging the summation terms for added and dropped products directly yields the product-switching level and allocation effects we have in Eq. (5). With the summation terms for continued products we proceed slightly analogous to the transformation we have done to achieve Eq. (2), i.e. we add and subtract $\sum_{p\in Pc} \Omega_{kjp0}\overline{C}_{kjpt}$ and

$\sum_{p\in Pc}\sum_d \Omega_{kjp0}\Delta\omega_{kjpdt}\Delta C_{kjpdt}$.

$$
\begin{aligned}
\Delta\lambda_{kjt}-\Delta\lambda_{kj0} &= \sum_{p\in Pc}(\Omega_{kjpt}-\Omega_{kjp0})\left[\overline{C}_{kjpt}+\left(\sum_d \Delta\omega_{kjpdt}\Delta C_{kjpdt}\right)\right] \\
&+ \sum_{p\in Pc}\Omega_{kjp0}(\overline{C}_{kjpt}-\overline{C}_{kjp0}) \\
&+ \sum_{p\in Pc}\sum_d \Omega_{kjp0}(\Delta\omega_{kjpdt}\Delta C_{kjpdt}-\Delta\omega_{kjpd0}\Delta C_{kjpd0}) \\
&+ \sum_{p\in Pc}\Omega_{kjpt}\overline{\lambda}_{kt}-\sum_{p\in Pc}\Omega_{kjp0}\overline{\lambda}_{k0} \\
&+ \sum_{p\in Pa}\Omega_{kjpt}(\overline{C}_{kjpt}-\overline{\lambda}_{kt})-\sum_{p\in Pd}\Omega_{kjp0}(\overline{C}_{kjp0}-\overline{\lambda}_{k0}) \\
&+ \sum_{p\in Pa}\sum_d \Omega_{kjpt}\Delta\omega_{kjpdt}\Delta C_{kjpdt}-\sum_{p\in Pd}\sum_d \Omega_{kjp0}\Delta\omega_{kjpd0}\Delta C_{kjpd0}.
\end{aligned}
\tag{12}
$$

The terms in the first three rows correspond to Eq. (2) which states the decomposition at the sector level. To get the expression of Eq. (5) the terms of the fourth row of Eq. (12) have to be implemented. We further add and subtract $\sum_{p\in Pc}\Omega_{kjp0}\overline{\lambda}_{kt}$. The terms $-\sum_{p\in Pc}\Omega_{kjp0}\overline{\lambda}_{kt}+\sum_{p\in Pc}\Omega_{kjp0}\overline{\lambda}_{k0}$ are used for the product level effect (VI) and the terms $\sum_{p\in Pc}\Omega_{kjpt}\overline{\lambda}_{kt}-\sum_{p\in Pc}\Omega_{kjp0}\overline{\lambda}_{kt}$ are used for the between product allocation effect (VII).