Adjusting to Globalization – Evidence from Worker-Establishment Matches in Germany *

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Abstract

We exploit rich worker-establishment data to trace the impact of rising international trade exposure in the job biographies of roughly 1.2 million manufacturing workers in Germany (1990-2010). Import penetration has substantial "push effects": It reduces earnings, and induces workers to leave the exposed industries. The industry movers typically perform worse than comparable stayers who keep their initial jobs, but this is different for highly able workers who benefit from mobility ex post. Export opportunities, by contrast, have only little "pull effects". Earnings gains arise within job spells, or through intra-industry reallocations, but there is little evidence for sorting into those industries.

JEL-Classification: F16, J31, R11
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1 Introduction

What are the labor market effects of "globalization"? Although a classical question in the economics literature that dates back, at least, to the seminal work by Stolper and Samuelson (1941), relatively little is known about the micro-level impacts of trade on the job biographies of heterogeneous individuals. How are different workers affected, depending on their initial sectoral affiliation, location, and personal characteristics? Do workers systematically adjust to trade by moving across industries, regions, or plants to mitigate import shocks or to benefit from export opportunities? Can we think of this mobility, if any, as voluntary job sorting in the wake of exogenous shocks, or rather as "forced" mobility after a disruptive unemployment spell? And how does all of this add up to the cumulative effect of trade on labor incomes in the medium-run?

In this paper, we use extensive data on worker-establishment matches in Germany to shed light on those questions, which appear to be a central concern for policy-makers who worry about the distributional consequences of globalization. The specific episode we consider is the fall of the iron curtain and the transformation of the former socialist countries in Eastern Europe, and the rise of China and its integration into the world economy. Those events, which happened quickly and unexpectedly for Germany, led to massively increasing imports from, as well as to surging exports to those markets. The pace of those changes was much faster than with respect to any other trading partner in the world (see Figure 1 below), making it the major globalization shock that hit the German economy in those two decades.[1] The structure of the rising trade exposure reflects specialization patterns according to comparative advantage. Indeed, we observe rising German exports in relatively skill- and technology-intensive manufacturing industries, such as automobile or special purpose machinery, and rising imports of goods from relatively labor-intensive sectors such as textile, office machinery, furniture, and so on. This, in turn, suggests that domestic workers from various industries may be affected differently by this globalization episode, as labor markets are not frictionless and do not instantaneously adapt to shocks in product markets.

Our aim in this paper is to provide detailed empirical evidence how these differential effects of trade play out in the job biographies and earnings profiles of roughly 1.2 million manufacturing workers in Germany. The data allow us to follow these individuals in the labor market over time, and we study how they were affected by, and responded to, the rising German trade exposure from the East in the period 1990-2010.

We consider three complementary empirical approaches. First, we start with a cross-sectional analysis along the lines of Autor et al. (2014). It identifies the effect of trade

[1] The consequences of the rise of China for US local labor market have been studied in an influential article by Autor et al. (2013). A similar analysis for German regions has been conducted by Dauth et al. (2014). This paper looks at the same globalization shock, but shifts focus and studies the micro-level impacts on the earnings profiles of single workers. Moreover, unlike the previous study, this paper is especially concerned with their individual labor market responses, i.e., how single workers adapt to rising trade exposure in their job biographies.

shocks to the initial industry, where the respective worker starts off in the base year, on the subsequent cumulated earnings and mobility patterns over a longer time horizon.

Second, we turn to a short-run model that fully exploits the panel structure of our linked employer-employee data, and that investigates how contemporaneous import and export exposure at the industry-level affects the workers' yearly earnings. This approach adds value in several respects. It tightly controls for time-invariant unobservable characteristics with individual-level fixed effects, thus addressing possible omitted variable bias, and it measures the actual trade exposure that a worker faces in every year, which may differ from the exposure of the initial sector of employment if a worker switches jobs across industries over time. Most importantly, the panel model allows us to explore in detail the role of worker selection and its associated compositional effects. We successively move from a basic panel model with worker dummies to more demanding specifications with worker $\times$ region, worker $\times$ (local) industry, or even worker $\times$ plant-fixed effects to estimate the impact of trade exposure on earnings.[2] When we only exploit the variation *within* worker-establishment spells, we purge our estimates from influences of worker sorting based on time-invariant characteristics. A comparison across specifications then allows us to gauge how important this sorting is in the adjustment to trade shocks, and also which type of sorting (across industries, regions, or establishments) is relatively most important.

Finally, building on Jacobson et al. (1993) we develop an event study approach to analyze how movers perform relative to comparable workers who stay in highly import-penetrated industries. This design highlights the *dynamics* of individual adjustment, and yields novel evidence on the nature of mobility responses induced by trade shocks.

Briefly previewing our main results, we robustly find that rising import penetration has an adverse impact on labor earnings of manufacturing workers in Germany, while rising export opportunities work in the opposite direction and tend to affect earnings more strongly. The bottom line is that this globalization episode has contributed to rising earnings inequality within Germany, both in the aggregate and for different groups in the labor market. For example, trade has caused more between- and within-group inequality for skill groups, where skills are identified by previously estimated worker fixed-effects similarly as in Card et al. (2013) and Abowd et al. (1999). We also find that younger workers are hit harder by imports, while women reap significantly smaller exporting gains than men although both sexes are hit similarly by imports.

Turning to the individual labor market adjustments, our key finding is that import penetration generates substantial mobility out of the exposed industries, often following an unemployment spell which occurs there with significantly higher probability. The workers who leave those industries are, however, typically not attracted by the expanding export-oriented manufacturing sectors, but they often move towards the service sector where they henceforth earn significantly less. The event study design, in

[2] See Foged and Peri (2015) for a similarly flavored analysis in the context of local labor supply shocks from immigration.

particular, shows that the typical mover experiences a much sharper decline before the move, often associated with job displacement and unemployment, and never catches up to previous levels afterwards. That typical mover is, thus, left with a stronger cumulative earnings decline than the typical stayer, which is suggestive that import shocks seem to exert notable "*push effects*" associated with losses of industry-specific human capital and medium-run losses. There is considerable heterogeneity in the data, however, and for workers with high ability we also find very different adjustment dynamics. They seem to deliberately (and supposedly voluntarily) sort out of import-penetrated industries, and afterwards perform significantly better than before.

Adjustments to rising export opportunities look very different. Here we observe that most of the earnings gains either accrue within worker-establishment matches for incumbent workers, or they arise via intra-industry reallocations of workers across establishments. But there is little evidence that the export-oriented manufacturing sectors attract workers who are "pushed out" from import-penetrated industries, or that workers with high ability sort themselves into export-oriented industries.

Related literature. Our study is related to a recent line of research that investigates the causal effects of trade liberalization on the job biographies of domestic workers. In two important studies for the US, Autor et al. (2013, 2014) find strongly negative effects of the rise of China on the cumulative earnings and other labor market outcomes of American manufacturing workers.[3] In this paper, we first follow their approach as a benchmark for the medium-run effects of trade. Comparing our results with theirs, we consistently find that rising import penetration per se adversely affects cumulated individual earnings in Germany. Yet, unlike in the US case, there is also a positive causal effect of rising export opportunities which tends to be stronger quantitatively. That is, if anything, we conclude that the average German manufacturing worker has gained from the rise of the East in terms of labor earnings, but still this globalization episode has benefited some manufacturing workers more than others.

Our work is also related to recent studies that investigate the worker-level impacts of trade using longitudinal linked employer-employee datasets. Menezes-Filho et al. (2011) and Dix-Carneiro and Kovak (2016) find that trade liberalization in Brazil triggers displacements and very limited absorption by export industries. Relatedly, the latter study also shows that trade shocks at the regional level have strongly persistent effects over time. Our results subscribe to their conclusion that labor markets do not adjust instantaneously to trade shocks as suggested by many textbook models. This seems to be true not only in the context of emerging economies, such as Brazil, but also for rich and strongly industrialized Western market economies like Germany.

There are also several studies in the European context. For instance, Hummels et al. (2014) analyze the effects of firm-level offshoring and exporting within given job spells

[3]Pierce and Schott (2016) have recently argued that this negative impact in the US labor market can be traced to changes in US trade policy, namely the granting of the permanent MFN status to China.

of Danish workers, as well as mobility and selection patterns induced by those activities.[4] Moreover, Balsvik et al. (2015) estimate the effect of rising Chinese import penetration on Norway's labor market, concluding that it can explain up to 10% of the reduction in the manufacturing employment share. In the present paper, we separately investigate import and export exposure for Germany, a large and very open economy, and similar to these studies we find causal effects of trade within job spells in addition to worker mobility that is triggered by rising trade exposure.[5]

Next, the literature has identified that trade shocks not only have direct effects on workers and firms, but they also affect sorting (Irarrazabal et al.; 2013) and the efficiency of worker-firm matching (Davidson et al.; 2014) and therefore induce indirect compositional changes. In this vein, Krishna et al. (2014) argue that the entire exporter wage premium in Brazil is due to unobserved differences in workforce compositions and disappears within job spells. We add to this literature by running panel models with interacted fixed effects that restrain the identifying variation. Thereby we gauge the relative importance of different sorting channels for our results.

Finally, our empirical study may also be informative as a source of model identification and validation for recent structural approaches of international trade. Traditional models with homogeneous workers predict cross-industry worker flows as well as intra-industry reallocations of workers towards more productive firms, see Helpman and Krugman (1985), Melitz (2003), or Bernard et al. (2007). These baseline models do not feature any wage dispersion or a differential impact of trade across equivalent workers. Those features arise, however, once labor market frictions are introduced, as for example in Egger and Kreickemeier (2009), Helpman et al. (2010), Davis and Harrigan (2011), Felbermayr et al. (2011), or Amiti and Davis (2012). In particular, recent models feature assortative matching of heterogeneous firms and workers within industries (see Yeaple (2005), Monte (2011), Helpman et al. (2012), Sampson (2014), or Davidson et al. (2014)) or sorting of workers across sectors given their industry-specific productivity realizations (Caliendo et al. (2015), Galle et al. (2015), Fan (2015), Dix-Carneiro (2014)). A common theme of these models is that exogenous trade shocks affect worker-establishment matches differently, and induce workers to adjust by moving across industries, regions, or plants. Those flows are then simulated in counterfactual analyses within the quantified general equilibrium frameworks, whereas our reduced-form approach is complimentary and provides empirical evidence how workers have actually responded to trade shocks in the data.

The rest of this paper is organized as follows. Section 2 describes the data and gives a descriptive overview. Section 3 introduces our medium- and short-run estimation approach, and Section 4 discusses the results. Section 5 considers heterogeneous effects of trade, and Section 6 present our event study design. Section 7 concludes.

[4] In related work, Ashournia et al. (2014) find a negative causal effect of Chinese import penetration on wages, and Keller and Utar (2016) study the impact on job polarization in Denmark.

[5] In another related study for Germany, Mueller et al. (2016) find that earnings losses from import shocks are smaller in more flexible locations that offer displaced workers a larger range of jobs.

2 Data and descriptive overview

2.1 Labour market biographies

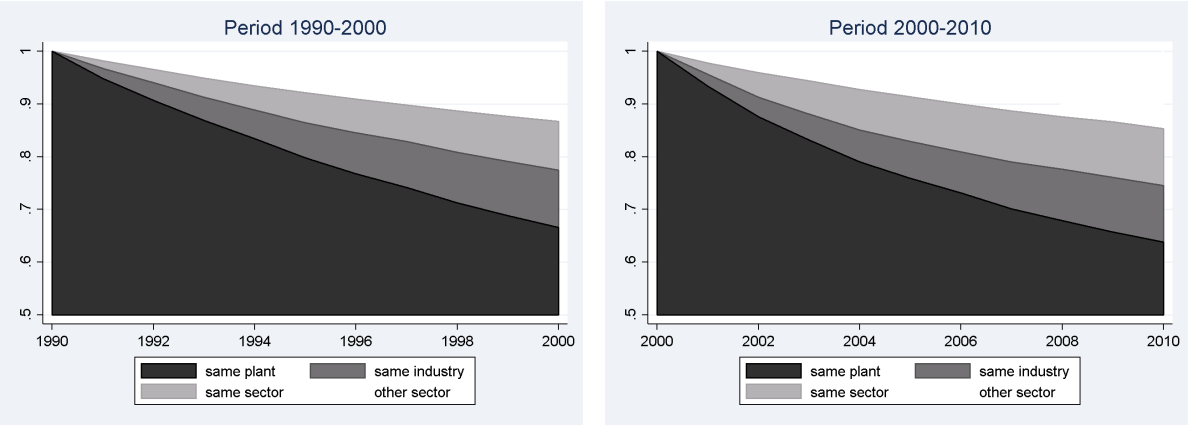
We use the Integrated Labour Market Biographies (IEB) from the German Institute for Employment Research, which essentially covers the universe of all workers in the German labor market except for civil servants and the self-employed.[6] A random 15% sample has been drawn from all persons who have either been employed or officially registered as job-seekers. This results in an individual-level spell data set that is highly accurate even on a daily basis due to its original purpose of calculating retirement pensions. With this administrative data, we can follow single workers over time, and keep track of all their on-the-job earnings changes, employer changes at the establishment level within and across industries and regions, as well as non-employment spells.

Our main observation period spans the time period from 1990 to 2010, which we split into two separate 10-year time windows. To construct our sample, we identify all individuals in either 1990 or 2000, who were between 22 and 54 years old, and were initially full-time employed in manufacturing. We eliminate those who died or moved to a different country. For the remaining roughly 1.2 million workers we then build a balanced annual panel which captures their entire work biographies over ten years.

These annual panels assign every worker to a 3-digit industry, a local labor market, and an establishment affiliation pertaining to the longest job spell held in every respective year. Whenever workers have non-employment spells in their job biographies that exceed one year, this may constitute long-term unemployment, early retirement, or labor market exit, all of which are endogenous labor market outcomes. We therefore keep those person-year cells in the data as observations with zero labor earnings and employment, and assign the respective worker to the last recorded industry, region and plant until he or she takes up a new job elsewhere.

Figure 1 gives an overview of the observed job mobility patterns in our samples. The dark areas show that almost 70% of the workers have not switched their employer, i.e., they work for the same establishment at the beginning and the end of the decade (or became unemployed and never took up another job). Roughly 30% of the individuals had *some* job switch, and the figure decomposes different types of mobility. It shows that less than 10% of the workers switched jobs within their original manufacturing industry (see the grey areas), which includes intra-industry plant switches in the same and in different regions. More than 20% changed the 3-digit industry when switching their employer, which can mean taking up a job in another manufacturing industry (light grey area) or moving to an industry that belongs to the service sector (white area). That is, conditional on switching, less than 33% of this mobility occurs *within* while more than 66% is *across* industries at the 3-digit level, and the latter type of mobility is often directed towards services and out of manufacturing altogether.

[6] See Oberschachtsiek et al. (2009) or Card et al. (2013) for an extensive introduction to this dataset.



(a) 1990-2000 (b) 2000-2010

Figure 1: Different types of labor mobility

Notes: The figures display the shares of workers who were employed in the manufacturing sector in the base year 1990 or 2000 by plant, industry, or sector affiliation during the following decade. Unemployed are assigned to their past plant until they take up a new job elsewhere.

For *earnings*, we add up all job spells during the respective year and calculate the annual labor income of every individual in every year. As the wage information is subject to right-censoring at the social security contribution ceiling, we apply the imputation procedure by Card et al. (2013). Moreover, we convert all earnings into constant 2010- € using the consumer price index of the *Bundesbank*. Finally, we express annual incomes in multiples of the individual's earnings in the base year (1990 or 2000).[7]

Table 1: **Descriptive overview: Earnings and individual trade exposure**

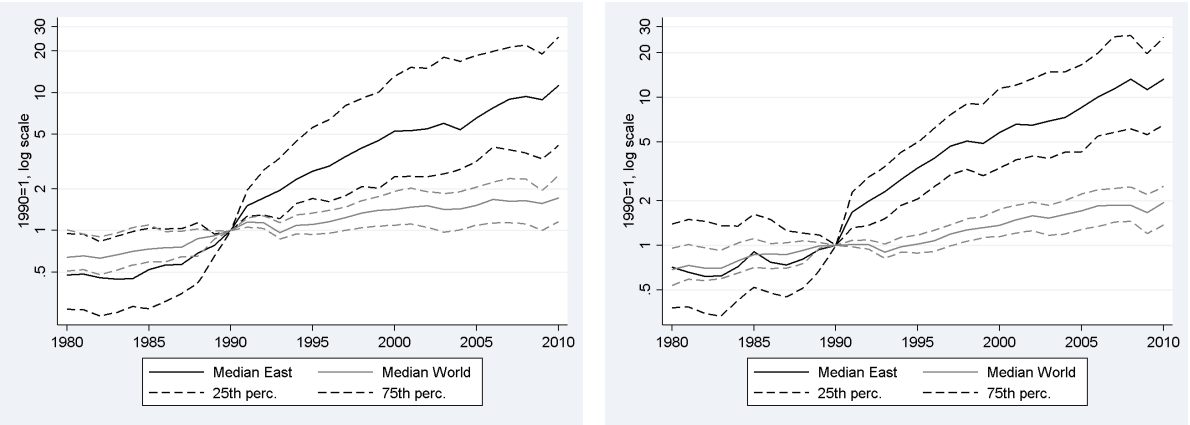
	mean	sd	1st quartile	median	3rd quartile
1990-2000					
base year earnings (in €)	42,636	22,177	30,569	37,478	47,429
cumulated / base earnings	8.6425	4.0807	5.7702	9.5171	10.9194
Δ import exposure	24.45	30.99	7.37	16.07	34.45
Δ export exposure	21.61	17.91	9.87	18.68	29.53
2000-2010					
base year earnings (in €)	45,334	31,348	30,557	38,231	48,784
cumulated / base earnings	9.0310	3.7219	7.3943	9.6639	10.7180
Δ import exposure	30.73	67.11	5.90	15.11	32.17
Δ export exposure	37.79	32.32	18.76	37.24	52.69

[7]This is a standard approach in the labor economics literature to take into account ex-ante earnings differences across workers. Notice that this normalized earnings approach is robust to observations with zero earnings in a year, which would not be the case if we had used (non-normalized) log annual earnings as the outcome variable. Instead of normalizing with base year earnings of a single year, we can also take an average over a few years. Results would not change.

Table 1 reports descriptive statistics. The first row shows that the average manufacturing worker in our sample had absolute annual earnings equal to 42,636€ in the base year 1990. That worker then experienced a real earnings loss, because cumulated earnings over the subsequent 10-year time window only add up to 8.64 times the base year value (see second line). This trend is similar, though somewhat weaker, in the second decade. At the same time there is strong variation across workers, which can be seen by comparing the 25^{th} and the 75^{th} percentile of the initial earnings distribution. While the former worker only recouped 5.77 times of his or her base year earnings in the following ten years, the latter made 10.91 times and thus experienced a notable real earnings gain during the first interval. Again we find a similar but less pronounced trend in the second decade. In sum, Table 1 conveys two basic messages: real labor earnings in the German manufacturing sector have been stagnating on average, and earnings inequality across manufacturing workers has soared

2.2 Trade exposure

Information on international manufacturing trade comes from the United Nations Commodity Trade Statistics Database (Comtrade). This data contains annual trade statistics of over 170 reporter countries detailed by commodities and partner countries, and trade flows are also converted into 2010-€. To merge them with our labor market data, we harmonize industry classifications by a correspondence between 1031 SITC rev. 2/3 product codes and the employment data at the 3-digit industry level (equivalent to NACE) as provided by the UN Statistics Division.[8] This yields information on international trade at the level of 93 3-digit manufacturing industries.



(a) Imports (b) Exports

Figure 2: Rising German trade volumes

Notes: The figures display the quartiles of German industry level import and export volumes, normalized to one in 1990 (log scale).

[8] Ambivalent cases were partitioned according to national employment shares in 1978.

Figure 2 illustrates the evolution of German industry-level trade, both with respect to the East and the world as a whole.[9] Trade volumes are depicted on a log scale and normalized to one in 1990, and the graphs capture the evolution across the industry distribution for the 25^{th}, 50^{th}, and 75^{th} percentile. The solid lines show that, at the median of the distribution, German trade volumes with the East increased by factor of ten between 1990 to 2010, both on the import and on the export side. This substantially out-paces the growth of trade with the world as a whole, which only doubled over the same period. The rise of trade exposure from the East started in the late 1980s, while the trends were flat before. It was particularly strong in the years immediately after the fall of the iron curtain in 1990/91, flattened out over the 1990s, and then received another boost in 2001 which coincides with the Chinese entry into the WTO.

As those events were sudden and largely unexpected, we may thus suspect that much of this observed increase in German trade stems from developments that originate in those countries, namely the vastly rising productivity and market access of China and the Eastern European countries as they were transformed into market economies (Autor et al. (2013); Pierce and Schott (2016)). This rising trade exposure then constitutes the major globalization "shock" that hit the German labor market in that period. But it does not only accrue in the form of rising import penetration from labor-abundant countries with substantially lower wages. It also involves the surging export opportunities which reflects the rising demand for German products from those areas.

Figure 2 also highlights the strong differences in industry-level trade exposure. The broken lines depict the evolution of the trade volumes of the industry at the upper and lower quartile of the respective distribution of trade increases. With respect to the East, imports and exports have increased across the whole industry distribution relative to 1990. However, there is considerable variation. In Table 2 we report the industries with the highest export and import volumes in 2010, and the evolution of their trade over time. As can be seen, the automotive industry has by far the highest export volume (and also the strongest increase over time), followed by other German export sectors such as special purpose machinery or chemicals. On the import side, the car industry also shows up high on that list as there is substantial intra-industry trade within that particular manufacturing branch. But we also see very different industries among those with the highest import penetration, in particular relatively labor-intensive industries like wearing apparel, furniture, or office machinery in which China and Eastern European countries have developed a comparative advantage.

Rising Eastern trade exposure, hence, affects workers very differently, depending on industry affiliation. To reflect this variation, we construct our main exposure measures

[9] The East is composed of China and 21 Eastern European countries, namely Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia, and the former USSR or its succession states Russian Federation, Belarus, Estonia, Latvia, Lithuania, Moldova, Ukraine, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan.

Table 2: **Industries with highest trade volumes with the East** (in billion € of 2010)

Exports	1990	2000	2010
341 motor vehicles	0.58	4.99	18.49
343 parts and accessories for motor vehicles	0.37	4.51	13.22
295 other special purpose machinery	2.29	4.68	10.00
291 mach. for the prod. and use of mech. power	0.54	2.61	8.96
241 basic chemicals	1.10	2.76	7.19
312 electricity distribution and control apparatus	0.22	2.54	6.80
292 other general purpose machinery	0.82	2.38	6.25
252 plastic products	0.21	2.85	5.70
294 machine-tools	1.36	2.09	5.61
244 pharmaceuticals	0.33	1.41	5.16
Imports	1990	2000	2010
300 office machinery and computers	0.05	3.71	13.61
341 motor vehicles	0.21	7.62	8.89
343 parts and accessories for motor vehicles	0.04	2.80	8.64
321 electronic valves and other components	0.02	0.82	8.25
182 other wearing apparel and accessories	2.57	6.52	7.86
323 television and radio receivers, recording app.	0.53	2.12	7.04
274 basic precious and non-ferrous metals	1.03	3.40	5.57
361 furniture	0.53	3.09	5.29
351 Building and repairing of ships and boats	0.01	0.27	5.14
316 electrical equipment n.e.c.	0.11	2.75	4.87

for import penetration and export opportunities in industry j as follows:

$$ImE_{jt} = \frac{IM_{jt}^{EAST \to D}}{\overline{w}_{j(t-1)} L_{j(t-1)}} \qquad \text{and} \qquad ExE_{jt} = \frac{EX_{jt}^{D \to EAST}}{\overline{w}_{j(t-1)} L_{j(t-1)}} \tag{1}$$

where $IM_{jt}^{EAST \to D}$ and $EX_{jt}^{EAST \to D}$ are aggregate national import/export volumes with the East in industry j and year t. We normalize them with a measure for sector j's overall size in the German economy, more specifically with the total domestic wage bill lagged by one year.[10] Table 1 reports descriptive statistics for the individual trade exposure measures (1). We there report the changes of ImE_{jt} and ExE_{jt} over ten years and find a notable heterogeneity across workers. For example, during the first decade, the worker at the 75^{th} percentile experienced a roughly five times stronger increase in import penetration than the the worker at the 25^{th} percentile, and almost a six times stronger increase during the second decade. Similarly, for exports we also find that rising opportunities in the East affected some workers much stronger than others.

[10]This approach follows Autor et al. (2014), who normalize trade flows with total domestic consumption. Directly replicating their normalization is not feasible in our context, because the required data for Germany are only available from surveys of larger firms and at a different level of aggregation.

3 Empirical approach

In this section, we first analyze the cumulative effect of trade on individual earnings and job mobility patterns over a ten year time horizon in a cross-sectional analysis. This approach follows Autor et al. (2014) and allows us to compare their results for the United States with our findings for Germany. Afterwards we turn to our short-run analysis that addresses individual adjustment to trade exposure on a yearly basis.

3.1 Medium-run analysis

For each worker i starting out in a manufacturing industry, we add up all labor earnings over the subsequent decade, irrespective of where they accrued, and divide them by the respective base-year labor income. We then regress these (normalized) cumulated individual earnings Y_{ij} on the increases in import and export exposure of the worker's *original* 3-digit industry j during the respective time period:

$$Y_{ij} = \boldsymbol{\alpha} \cdot \mathbf{x}'_{ij} + \beta_1 \cdot \Delta ImE_j + \beta_2 \cdot \Delta ExE_j + \phi_{REG(i)} + \phi_{J(j)} + \phi_{1990-2000} + \epsilon_{ij} \qquad (2)$$

In the vector $\mathbf{x}_{ij}$ we include standard worker-level controls, namely dummies for gender, foreign nationality, 3 skill categories, 3 tenure categories, 7 age groups, and 5 plant size groups. Moreover, we add dummies for Federal States $\phi_{REG(i)}$ and 10 broad manufacturing industry-groups $\phi_{J(j)}$, as well as a time period dummy $\phi_{1990-2000}$ to differentiate the two cross-sections. Standard errors are clustered by industry $\times$ base year.

The main idea behind this medium-run approach is that the workers' initial industry affiliations in the respective base year are, arguably, orthogonal to the subsequent rising trade exposure. In other words, given that the fall of the iron curtain and the rise of China occurred quickly and unexpectedly, the assumption is that workers have not sorted into particular industries prior to the base year in anticipation of the future trade. The empirical model (2) then uncovers how worker i's cumulative earnings over the full decade are affected by trade shocks to the initial industry j.

Some important identification issues arise. First, the two main coefficients, β_1 and β_2, only capture causal effects when there are no parallel unobservable shocks that simultaneously affect trade and labor market outcomes. To address this concern, we follow common practice and instrument the exposure variables with trade flows of other countries vis-a-vis the East.[11] Moreover, in another approach, we rely on residuals from a preceding gravity equation (see the Appendix for more details). Those residuals capture the increase in competitiveness of the East relative to Germany, and

[11] This instrumental variable approach has been developed by Autor et al. (2013) and applied to the German case by Dauth et al. (2014). We follow their approach, and use the trade flows of Australia, New Zealand, Japan, Singapore, Canada, Sweden, Norway, and the UK to construct the instrument by replacing the numerators of ImE_{jt} and ExE_{jt}, respectively. The rationale is that demand shocks in those "instrument countries" are largely uncorrelated with German ones, and have little direct effects on German workers. On the other hand, those countries are similarly affected by the rise of the East.

its rising attractiveness as an export market relative to other destinations. Thereby we neutralize possible confounding demand and supply shocks that could jeopardize identification, without having to rely on an instrumental variable approach.

Second, confounding long-run trends could bias our results. In particular, theories of structural change predict a decline of manufacturing and a rise of services in advanced economies such as Germany, so that some industries may have been on a declining (growing) trend well before the 1990s. When China and Eastern Europe entered the stage, this may not have causally affected earnings profiles, but the rising imports (exports) from (to) those areas could also be symptoms of the previous industry-specific trajectories. To address this concern, we identify all effects *within* broad industry groups and thereby purge the estimates of long-run trends of industrial change. Moreover, we consider a placebo test below to analyze if past earnings changes predict future trade exposure, and do not find such a correlation.

Finally, one might worry about confounding region-specific trends, since the German reunification and the associated economic changes took place at the start of our observation period. We therefore use fixed effects and identify all effects only *within* particular Federal States. Moreover, the instrumental variable approach purges the results of Germany-specific shocks, including those stemming from reunification.[12]

In the baseline specification of (2), we use the individuals' total cumulative earnings as the outcome variable and thereby study the overall medium-run impact of rising trade exposure on labor income. Afterwards, as in Autor et al. (2014), we decompose Y_{ij} into different additive parts, and estimate if trade shocks to the original industry have led workers to change jobs (and to collect earnings) within or across industries. This first analysis of the individual *adjustment* to globalization is then carried further in the short-run panel approach.

3.2 Short-run panel analysis

Turning to the second approach, we there investigate how *contemporaneous* trade exposure affects *yearly* earnings. We now follow the workers who start out in manufacturing over the next ten years on an annual basis, by running a panel estimation of this form:

$$Y_{ipjrt} = \mathbf{x}'_{it}\boldsymbol{\alpha} + \beta_1 \cdot ImE_{jt} + \beta_2 \cdot ExE_{jt} + \phi_{t,J(j)} + \phi_{t,REG(r)} + \gamma_{i,u} + \epsilon_{ipjrt}, \qquad (3)$$

where $u = \{p, jr, j, r\}$. Here, Y_{ipjrt} are annual earnings of individual i, working in establishment p, 3-digit industry j, and local labor market r in year t, again normalized by the respective worker's annual earnings in the base year. The industry-level trade exposures from (1) now refers to the current industry affiliation in year t, and we analogously use third-country trade flows in that year as instruments. Moreover, we include industry group $\times$ year and Federal State $\times$ year fixed effects to control for

[12] As a further robustness check we also exclude East Germany entirely and focus only on West German manufacturing workers. See Section 4.2.5. below.

broad sectoral and regional trends.[13]

This short-run analysis in (3) differs in three main respects from the previous cross-sectional approach in (2). First, it exploits the full panel structure of our data and tightly controls for worker characteristics with individual-level fixed effects. Thereby it identifies the effects of trade on earnings from particular variations *within* the biography of single workers, whereas the previous model (2) mainly relied on the variation *between* different workers controlling for several observable characteristics.

Second, the panel model captures the actual trade shocks that a worker faces in every year, as it keeps track of industry switches which lead to a changing exposure. The following example illustrates this point: Consider a person i who initially works in industry $j = 1$, but moves to another industry $j = 2$ already in the first year after the base period. This worker is, thus, confronted with the rising trade exposure of $j = 2$ for nine years in our sample, and to $j = 1$ only for a single year, and the short-run model accurately captures this exposure profile. The medium-run model, however, measures the individual trade exposure only based on import and export volumes of the *original* industry $j = 1$ over ten years. It thereby quantifies the medium-run consequences of trade shocks to the worker's initial job, whereas the short-run model identifies the partial effect of trade exposure on earnings from *all* job spells during the respective decade, which may involve multiple subsequent industry affiliations.

Third, the panel model allows us to investigate how important worker selection is in the data. In the medium-run analysis, selection is less of an issue since initial industry affiliations are reasonably orthogonal to later sectoral import and export changes. In the short-run analysis, however, it is clearly important, because heterogeneous workers may adjust by sorting into particular industries over time, and the resulting compositional changes may be confounded with the effects of trade.[14]

To address this sorting, we include interacted individual-level fixed effects which restrain the identifying variation behind our central coefficients β_1 and β_2. We start from an encompassing approach with dummies for every worker γ_i, and then successively move to more demanding specifications with worker $\times$ region, worker $\times$ (local) industry, or even worker $\times$ plant-fixed effects. When we only exploit the variation *within* worker-establishment spells in the $\gamma_{i,p}$-model, we eliminate all earnings effects stemming from sorting based on time-invariant characteristics and come closer to the *direct* effects of trade.[15] A comparison to the results of the γ_i-model with only individual-fixed effects, which exploits the workers' total earnings variations and thereby captures also indirect compositional effects, then allows us to gauge how important sort-

[13] In the vector x_{it} we only have the squared and cubic term of the worker's age, since all other standard characteristics (such as gender, skill, etc.) are absorbed by the various fixed effects and trends.

[14] See Irarrazabal et al. (2013) for a related argument in the context of firms' exporter wage premia.

[15] Krishna et al. (2014) show that a model with match-specific fixed effects may still capture compositional effects if worker i's productivity is itself a time-varying function of in plant p's trade exposure. However, when match-specific productivity is time-invariant as in recent theoretical models such as Helpman et al. (2010), the $\gamma_{i,p}$-model identifies the pure effects of trade exposure purged of all sorting.

ing (induced worker mobility) is in the adjustment to trade shocks. Furthermore, by identifying effects within industries or regions, but across plants, we shed light on the relative importance of different types of adjustment.

In sum, the two complimentary models in (2) and (3) therefore approach the data from different angles, and exploit different variations to shed light on the effects of rising trade exposure on labor earnings and mobility patterns in Germany.

4 Results

4.1 Medium-run results

Table 3 reports the results of the cross-sectional analysis. In column 1 of the upper panel A, we first estimate model (2) by ordinary least squares (OLS), while columns 2 and 3 refer to the first stage results when German trade exposure is regressed on the trade flows of the third countries. As can be seen, the instrument appears to be strong and all coefficients have the expected sign. In particular, both import and export exposure are predominantly predicted by their respective instrument counterparts. Our main result is then in column 4, which refers to the second-stage results of the instrumental variable estimation.[16]

4.1.1 The overall effect of trade on earnings in the medium-run

In column 4 of panel A, we find that cumulative earnings over ten years are reduced by about 0.09 percentage points for every percentage point increase in import exposure of the original industry j. A stronger rise in export exposure, by contrast, leads to an increase of cumulative earnings by about 0.44 percentage points.[17] To convert these estimates into economically meaningful magnitudes, consider a worker with median annual income in the base year 1990 (37,478 €, see Table 1) who experiences a rise in import exposure at the 75^{th} percentile ($\Delta ImE_j = 34.45$) and compare to a worker with median income but import exposure at the 25^{th} percentile ($\Delta ImE_j = 7.37$). Our estimates imply that the former earns $-0.09 \times (34.45 - 7.37) \times 37,478/100 = -913$€ less than the latter over ten years, because of the stronger rise in import penetration. Performing an analogous interquartile comparison for export exposure, we find an earnings difference of $0.44 \times (29.53 - 9.87) \times 37,478/100 = +3,242$ € in the first decade. For the second decade, the magnitudes are -903 € for imports and $+5,707$ € for exports.

To be sure, those numbers must be read as *relative* effects of trade. In other words, our empirical approach does not allow us to investigate how workers in the German labor market were affected by the rising trade exposure in *absolute* terms. What our

[16] Columns 1 and 2 show that the OLS estimator yields (slightly) downward biased results. This is intuitive, because it does not purge Germany-specific unobserved demand shocks.

[17] The coefficients for the other control variables all have the expected signs and are precisely estimated. The full results tables are available upon request from the authors.

Table 3: **Medium-run results**

[A] Baseline	(1) OLS	(2) 1st Stage ImE	(3) 1st Stage ExE	(4) 2SLS	
import exposure	-0.0723***	0.2044***	0.0242***	-0.0901**	
	(0.024)	(0.027)	(0.005)	(0.038)	
export exposure	0.4157***	0.1965***	0.2259***	0.4384***	
	(0.070)	(0.034)	(0.024)	(0.132)	
R^2	0.155	0.538	0.555	0.155	
1st Stage F		53.075	62.016		
[B] Robustness	(1) Incl. downstream links	(2) Net, 2SLS	(3) Gravity	(4) Placebo	
import exposure	-0.0862**				
	(0.038)				
export exposure	0.4856***				
	(0.123)				
net trade exposure		0.1002**	0.6721***	0.0578	
		(0.040)	(0.128)	(0.036)	
[C] Adjustment	(1)	(2)	(3)	(4)	(5)
(earnings components)	All employers		Same sector		Other Sector
Same 2-dig industry		yes	yes	no	no
Same employer		yes	no	no	no
import exposure	-0.0901**	-0.2003**	-0.0953**	0.0208	0.1846***
	(0.038)	(0.092)	(0.042)	(0.018)	(0.051)
export exposure	0.4384***	0.3539	0.4015**	-0.0784	-0.2386**
	(0.132)	(0.244)	(0.178)	(0.068)	(0.108)
[D] Linear probability	(1)	(2)	(3)	(4)	(5)
(job switches)	ever becomes unemployed		stays in sector		Leaves Sector
Stays in 2-dig industry		yes	yes	no	no
Stays in firm		yes	no	no	no
import exposure	0.0136***	-0.0250**	-0.0107**	0.0001	0.0357***
	(0.005)	(0.012)	(0.005)	(0.003)	(0.011)
export exposure	-0.0551***	0.0310	0.0279*	-0.0041	-0.0548**
	(0.013)	(0.033)	(0.017)	(0.009)	(0.028)
[E] Smooth biographies	(1)	(2)	(3)	(4)	(5)
(earnings components)	All employers		Same sector		Other Sector
Same 2-dig industry		yes	yes	no	no
Same employer		yes	no	no	no
import exposure	0.0267	-0.1887*	-0.1321*	0.0522	0.2952***
	(0.042)	(0.110)	(0.069)	(0.032)	(0.085)
export exposure	0.2927**	0.0727	0.6475**	-0.1490	-0.2785*
	(0.130)	(0.289)	(0.254)	(0.096)	(0.154)

Notes: Based on 1,177,112 workers. Additional controls are indicators for gender, foreign nationality, 3 skill categories, 3 tenure categories, 7 age groups, 5 plant size groups, 10 manuf. industry groups, and Federal States. Standard errors, clustered by industry x base year in parentheses. The outcome variable in panels A, B, C and E is cumulated earnings over 10 years normalized by yearly earnings in the base year. In Panel D the outcome variables are binary indicators for job switches. Panel E replicates Panel C for a subsample of 554,982 workers with no day of unemployment in the respective 10 year period.

results do show, however, is that some workers were hit harder by import shocks than others, and that some benefited more than others from the rising export opportunities. The latter channel seems to be particularly important, because the effects on the export side are quantitatively much larger than on the import side. This result is qualitatively different from the key message of Autor et al. (2014), who find considerable earnings losses in the US manufacturing sector from rising Chinese import penetration but little to none offsetting earnings gains from increasing export opportunities. The German labor market, thus, seems to have responded quite differently than the American one to this globalization episode, and similarly as in the aggregate analysis by Dauth et al. (2014), our results suggest that the average German manufacturing worker has gained.

In panel B of Table 3, we consider several robustness checks of those baseline results. First, since trade shocks may be transmitted along the value chain, we augment the previous measure for industry j with the weighted exposure in downstream industries similarly as in Acemoglu et al. (2016).[18] When using those comprehensive measures, we estimate roughly similar coefficients as in column 4 of Table 3. This suggests that our results remain robust when taking input-output linkages into account.

Next, we consider the alternative strategy where *net* trade exposure is measured by the residuals of a preceding gravity estimation (see Appendix). For reference, we first report in column 2 the instrumental variable result when using the net exposure of industry j constructed from (1), instead of import and export exposure separately. That exercise yields very similar quantitative predictions as before. The coefficient in column 3 is also highly significant, and multiplied with the observed changes in the gravity measure implies consistent (though somewhat more conservative) magnitudes.

Finally, we are concerned that our results may pick up industry-specific pre-trends. To explore this possibility, we run a placebo regression to analyze if there is a correlation between past earnings trends and the future rise of trade exposure. Specifically, we regress cumulated earnings 1981-1990 of manufacturing workers in 1980 on the increase of net export exposure over the period 1990-2010, controlling for the same variables as in the baseline and using analogous instruments. We obtain an insignificant and small estimate in column 4, which is reassuring that our results do not capture industry trajectories but causal effects of rising trade exposure.

4.1.2 Adjustments to trade shocks in the initial industry

So far we have studied total cumulative earnings over ten years, irrespective of where they accrued. Turning to panel C of Table 3, we now decompose Y_{ij} into different parts and add up all earnings that worker i has collected during the respective decade in the original establishment, in different establishments within the same manufacturing

[18]The intuition is that the steel industry, for example, is not only directly affected by import shocks, but also indirectly as other negatively affected sectors may demand less raw steel. Similarly, the car parts industry not only benefits directly from more export opportunities, but also via its most important downstream customer, the automotive industry. See the Appendix for more details.

industry, in different manufacturing industries, or outside of manufacturing. In column 1 we first repeat our estimation from column 4 of panel A, and in columns 2–5 of panel C we then investigate how trade shocks to the initial industry j have affected the different additive components of total cumulative earnings.[19]

Looking first at rising import exposure, in colums 2 and 3 we find strongly negative effects on earnings in the original establishment and in subsequent jobs within the same industry. Columns 4 and 5 then show that import-exposed workers still acquire stronger earnings gains elsewhere. That is, they do seem to adjust to import shocks by changing jobs, more specifically, by moving out of the affected industries. But with this mobility, they can only partly make up for the losses that were already piled up (by roughly $\frac{0.18+0.02}{0.20+0,095} \approx 66\%$), so they are left with lower cumulative total earnings.

Interestingly, the individual adjustment to import penetration almost exclusively takes the form of moving towards the service sector. In column 4 we find no effect on earnings in other manufacturing industries, while there is a large and highly significant effect in column 5 for earnings acquired outside of manufacturing. A similar pattern emerges in panel D of Table 3, where we exchange the outcome variable and consider a linear probability model for job changes. More import-exposed workers, firstly, have a lower chance to remain in their original job or industry, and a higher chance of becoming unemployed. Moreover, consistent with the earnings results from panel C, we find a much higher probability to move towards the service sector, but virtually no effect on the probability to move towards a different manufacturing industry.

Adjustments in response to rising export opportunities are very different. Panel C shows that the overall gain in labor income is composed of higher earnings in the original job (column 2) and in other jobs in the same industry (column 3), although the former is less precisely estimated. Consistently, we find in panel D that export shocks raise the chance to keep the original job and for switches within the same industry, while they reduce the chance that a worker leaves or becomes unemployed.

Summing up, our results suggest that import penetration exerts considerable *push effects* while export opportunities do not seem to invoke comparable *pull effects*: Workers from import-competing manufacturing industries do not typically reallocate towards expanding export-oriented branches, but they tend to be "pushed out" of manufacturing altogether and are left with medium-run earnings losses.[20] In the export-oriented sectors, by contrast, we observe that incumbent workers realize earnings gains on the job, and through intra-industry reallocations across establishments along the lines of the seminal trade model with heterogeneous firms by Melitz (2003).

[19] Notice that the coefficients in columns 2–5 must thus add up to column 1 in panel C of Table 3.

[20] This resembles the findings of Menezes-Filho et al. (2011) and Dix-Carneiro and Kovak (2016) for Brazil, where workers displaced by trade policy changes are also often pushed into the informal segment of the labor market. Autor et al. (2014), by contrast, find more transition of import-exposed workers in the US towards different manufacturing industries and no significant pushes into the service sector (see their Table IV), although some of their non-classified firms may actually be in services.

4.1.3 Smooth versus bumpy job careers

Individual adjustment to trade shocks can take various forms, such as wage and employment changes on the same job, uninterrupted job-to-job transitions, as well as transitions into and out of unemployment. For the latter, we have already seen that rising import (export) exposure increases (lowers) the risk for an individual to ever become unemployed. We now further investigate the importance of this channel by comparing our baseline results to the responses to trade exposure in a subsample of workers for which disruptions in job biographies play absolutely no role.

We construct a sub-sample and only keep such persons who were constantly employed on each day of the respective decade. Earnings changes for them can, thus, only arise on-the-job or by smooth job-to-job switches, but they do not involve even very short unemployment spells (not even a single day). This leads to a notable reduction in the number of observations: Before our estimations were for 1,177,112 workers, and now we have only 554,982 of them left. Those workers with extremely steady careers are, of course, not a random but supposedly a positively selected sample. Yet, by comparing this group to the overall sample from panel C, we gain insights what role unemployment spells play in the individual adjustment to trade shocks.

In panel E of Table 4 we repeat all specification from panel C. The key difference is that workers with smooth biographies do, on average, not suffer from cumulative earnings losses due to import shocks. Also for this subsample, we find induced job changes into the service sector but little mobility towards a different manufacturing industry.[21] But those steady workers fully recoup all earnings losses piled up in the initial industry by the higher earnings received later elsewhere. This suggests that painful "push effects" of import shocks are the typical pattern that we observe when considering all workers, and that unemployment spells are a key component behind the resulting cumulative earnings losses. However, there is quite some heterogeneity in the data, and for the steady workers we find that induced industry mobility does not have to involve medium-term losses. We will come back to this heterogeneity of mobility patterns in the event study approach below in Section 6.[22]

4.2 Short-run panel results

Table 4 turns to the estimation results for the short-run panel model (3). The five columns refer to different specifications of the interacted fixed-effects $\gamma_{i,u}$ which restrains the identifying variation as explained in Section 3. In the upper panel A we

[21] We omit the linear probability model for this subsample to save space, but it yields consistent results to those for additive earnings components shown in panel E.

[22] Briefly comparing the results for export exposure, we find that the steady workers receive also lower earnings gains that the entirety of all manufacturing workers. This may come from several factors, including i) the level of base year earnings is higher for this positively selected worker subsample, so that cumulated overall earnings are deflated more strongly, and ii) very stable careers may also indicate strong risk aversion, and low search efforts for potentially better paid jobs. This can, in turn, materialize in lower earnings gains from rising export opportunities.

report the baseline results pertaining to all manufacturing workers , while panel B considers the same subsample of workers with very smooth biographies just introduced.

Table 4: **Short-run panel results**

	A) All manufacturing workers				
	(1)	(2)	(3)	(4)	(5)
import exposure	-0.0400***	-0.0410***	-0.0422***	-0.0297***	-0.0259***
	(0.0048)	(0.0050)	(0.0050)	(0.0032)	(0.0029)
export exposure	0.1046***	0.1083***	0.1097***	0.0941***	0.0920***
	(0.0182)	(0.0189)	(0.0193)	(0.0134)	(0.0123)
Fixed effects	i x p	i x j x r	i x j	i x r	i
Groups	1686734	1598380	1547363	1413779	1230159
R^2	0.628	0.622	0.614	0.599	0.570
KP	60.614	54.047	54.263	76.624	88.148
	B) Steady workers with smooth job biographies				
	(1)	(2)	(3)	(4)	(5)
import exposure	-0.0137***	-0.0150***	-0.0151***	-0.0102***	-0.0099***
	(0.0038)	(0.0041)	(0.0040)	(0.0029)	(0.0025)
export exposure	0.0878***	0.0946***	0.0943***	0.0709***	0.0678***
	(0.0138)	(0.0149)	(0.0148)	(0.0114)	(0.0106)
Fixed effects	i x p	i x j x r	i x j	i x r	i
Groups	725596	680451	661189	620971	569718
R^2	0.508	0.500	0.494	0.484	0.461
KP	67.160	60.167	60.471	68.588	75.718

Notes: The dependent variable in all specifications 100 x annual earnings normalized by base year earnings. Upper panel: 13,531,749 observations of 1,230,159 workers. Lower panel: 6,266,898 observations of 569,718 workers. On top of different fixed-effects across columns, all models include industry group (at the 1 digit level) times year and Federal State times year fixed effects, and age squared and age cubic.

4.2.1 Baseline short-run results

The most demanding specification is in column 1, where we introduce worker×plant-fixed effects $\gamma_{i,p}$ and identify the coefficients β_1 and β_2 only from the yearly variation of earnings and trade exposure *within* worker-establishment matches. Starting with the effects of import penetration, we find that an increase by one percentage point leads to a reduction of normalized annual earnings by -0.040 percentage points within worker-plant matches. This effect is around 60% larger than the coefficient of -0.0259 in column 5, which is identified from the overall annual variation in trade and earnings in the respective worker's job biography during a decade, both within and across differ-

ent job spells, and thus includes the variation between jobs for every single worker.[23] The comparison suggests that import shocks have indeed triggered substantial individual mobility responses, and that workers mitigated the adverse impacts of import penetration on earnings by moving towards less exposed industries.

Stated differently, recognizing that mobility may result from sorting based on unobservable characteristics, the coefficient in column 5 captures not only the causal short-run effect of import penetration on yearly earnings, but also possible compositional effects as workers adjust. In column 1, however, the impacts of sorting based on time-invariant characteristics are purged. There may still be compositional effects in the $\gamma_{i,p}$-model, if worker i's productivity in plant p is itself a time-varying function of the establishment's trade exposure.[24] However, the $\gamma_{i,p}$-model comes closer to the *pure* earnings effects of import penetration, which are stronger negative than the coefficient of the γ_i-model: Workers sort out of import-exposed establishments.

The models in columns 2–4 range in between. Here we only exploit the variation within locations, industries, or local industries and thereby purge the coefficients of particular types of adjustments, while still allowing others to influence our estimates. Comparing the different specifications then allows us to address which types of mobility are relatively more important for workers to respond to trade shocks. We find that the coefficient for import exposure in the $\gamma_{i,j}$- and the $\gamma_{i,jr}$-models in columns 2 and 3 are almost identical, and very similar to the $\gamma_{i,p}$-model from column 1. This suggests that workers respond to negative import shocks – which are by construction industry-specific in our empirical approach – mostly by moving across industries. It does not seem to be important whether this adjustment takes place locally within the same region, or in a different region. This conclusion is also supported in column 4, where we identify the effects within regions but across industries. The coefficient of the $\gamma_{i,r}$-model is very similar to the γ_i-model in column 5. In other words, industry mobility seems to be the key adjustment channel, whereas regional mobility (within the same industry) plays a minor role in the adjustment to import shocks.

Turning to the effects of rising export opportunities, we observe some differences across specifications in Table 4, but overall those differences are much smaller and statistically not significant. In column 1, we observe a positive effect of export shocks *within* worker-establishment matches, which is in line with the existence of a causal exporter wage premium in Germany (Baumgarten (2013), Schank et al. (2007)). This effect hardly changes, however, when additional variation between job spells and the corresponding compositional effects are taken into account in columns 2–5. In other

[23] The following example illustrates the difference: Suppose a person works in plant 1 for three years, then switches to plant 2 (which operates in a different industry and, thus, exhibits different trade exposures) during the fourth year, and then works for six years in that establishment. The $\gamma_{i,p}$-model only captures the earnings profile during the first three and the last six years, but not the (upward or downward) change when the plant switch occurs. That variation is included, however, in the γ_i-model.

[24] See Krishna et al. (2014) for an in-depth discussion. Also see Abowd et al. (2015) from the labor economics literature on the related issue of wage determination with endogenous worker mobility.

words, also in the panel analysis there is no evidence that productive workers sort into export-oriented industries. If this were the case, we would expect a larger positive coefficient in column 5 than in columns 1–3, but if anything, we observe the opposite.

4.2.2 Quantitative bechmarking and comparison to medium-run approach

The results of the short-run panel model are consistent with the previous medium-run approach. First, as before, we observe that the marginal effect of rising export exposure is substantially larger than the corresponding coefficient for import penetration in all specifications. Second, the short-run results also indicate an asymmetry in the *push effects* of import and the *pull effects* of export shocks: While the former seem to trigger substantial mobility out of the import-penetrated industries, we cannot infer that the latter induce adjustments into the export-oriented sectors.

To translate the short-run results into meaningful magnitudes, we proceed as follows: we compute the history of trade exposure for every worker by keeping track of all industry affiliations over time, and by multiplying the respective changes of ImE_{jt} and ExE_{jt} in every year with the respective coefficients from column 1 of Table 4. This gives us the short-run effect of trade for every individual worker in every year. To obtain the total effect of trade in a worker's biography, we thus multiply each short-run effect by the number of years to the end of the decade before summing up all effects and multiplying this with the respective base year earnings. Comparing the quartiles of the resulting distributions, we obtain earnings differences due to varying import/export exposure of -1302€ and $+3004$€ over ten years in the first, and -1853€ and $+6702$€ in the second decade. These effects reflect the sum of yearly short run exposures but neglect any the mitigating effects of mobility. Repeating this exercise for the results of column 4 of Table 4, where endogenous adjustment is considered, yields substantially smaller import effects of -900€ in the first and -1396€ in the second period, and those effects are then also roughly similar to the predictions of the medium-run analysis.

In conclusion, the consistency of the medium- and the short-run approach is reassuring, because the latter approach addresses the dynamics of individual adjustments to trade shocks and corresponding issues of worker selection quite differently than the former. Still, the two analyses deliver results in the same ballpark and may provide a sensible corridor how trade has affected individual earnings profiles in the German manufacturing sector.

4.2.3 Smooth versus bumpy job careers

To investigate the role of unemployment spells in those short-run impacts, we repeat in panel B of Table 4 all specification from before, but focus again on the sub-sample of workers who never experienced unemployment. Comparing the results for this subsample to the overall sample of all workers, we obtain a general picture that is consistent with the medium-results from panels C and E of Table 3.

First, the key difference between panels A and B in Table 4 is that the steady workers suffer much less from import shocks. Comparing the results for the $\gamma_{i,p}$ models in column 1, the coefficients are -0.0400 versus -0.0137, and for the γ_i models in column 5 we have -0.0259 versus -0.0099, respectively. That is, earnings losses within and between job matches are less than half for the steady workers than among all manufacturing workers at large, and once the variation between different jobs is taken into account in column 5, the negative effect disappears almost completely for the steady workers. Furthermore, the coefficients in columns 1–3 of panel B are very similar and roughly 50% larger than the coefficients in columns 4 and 5. This pattern is similar as in panel A, which shows that import shocks also induce mainly industry mobility among the steady workers for whom all transitions happen smoothly.

Second, for export exposure we again find similar coefficients across specifications in panel B, which tend to be much larger than the import effects. Comparing panels A and B, there are somewhat smaller export effects for the subsample of steady workers than for the entirety of manufacturing workers which is also in line with Table 3.

4.2.4 Moving into manufacturing

One potential problem with our conclusion that export opportunities do not have strong pull effects is that our sample only consists of workers who started out in manufacturing. While we follow those individuals if they leave for a job in the service sector, we do – by construction – not take into account initial service employees who later switched into a manufacturing job.

To investigate this possible bias, we have changed our sample and now also include service workers who moved into manufacturing at some point during the respective decade. While still in the service sector, we either assign them with zero trade exposure (see Table A.2), or as an additional robustness check we define trade exposure more comprehensively to include also downstream linkages (see Tables A.3 and A.4) which then leads to positive import and export exposures also for service industries. In all cases, we obtain similar results as in Table 4. Our main results are, thus, unaffected when taking those service-to-manufacturing movers into account.

4.2.5 Only West Germany

Finally, we also conduct another robustness check and drop East Germany entirely from the analysis. Although the Federal State dummies and the instrumental variable approach should already address this concern, one might still worry that there are systematic differences in how manufacturing workers are affected by, and respond to trade shocks in the two parts of the country. However, as can be seen in Table A.5, the results are almost identical to our baseline findings, which likely reflects the fact that manufacturing at large is strongly concentrated in the area of former West Germany.

5 Heterogeneous effects across workers

The distributional effects of globalization are a central concern in the current policy debate, and identifying groups of winners and losers can potentially help to design targeted policies. Therefore, before moving to our third empirical strategy – the event study design – in the next Section, we first explore the impacts of rising trade exposure in various subsamples of workers with varying characteristics (age, gender, formal education levels, unobserved ability, and initial workplace quality), using the same set of high-dimensional fixed effects models as before.[25]

5.1 Age

Table 5 reports the results when we split the sample along the median age at the start of the period (38 years). Strikingly, the estimates show that trade shocks affect the young much more than the old workers, in fact in both directions. In particular, the import and the export effects are roughly twice as large in panel A than in panel B for comparable specifications. For the old workers, we also find that all coefficients are rather stable across the different models, i.e., there seem to be little compositional effects due to sorting for those individuals. For the young workers, on the other hand, we observe notable mobility responses (compare columns 1 and 5 in panel A), but again no sorting of productive young workers into export-oriented sectors.

These results are in line with a large literature in labor economics showing that young workers are more like to face layoffs or wage cuts in the event of negative shocks, and our study shows that this logic also pertains to rising import penetration. Moreover, we find that industry mobility helps those workers to mitigate the adverse impacts at least partly. The labor incomes of older workers, by contrast, exhibit less variation overall and are, thus, also more insulated from rising trade exposure.

5.2 Gender

In Table 6 we split our sample by sex. The most remarkable finding here is that the adverse effects of import penetration are equally strong for both sexes, but the earnings gains from rising export exposure are much stronger for men than for women (by a factor of three). This pattern is particularly pervasive *within* job matches (see column 1), and smaller when compositional effects are included (see column 5). More specifically, there is evidence that productive women self-select into export-oriented sectors. This can be inferred from the larger coefficient in column 5 of panel B, which suggests that the variation between job spells adds to the overall earnings gains for women. But even including those effects, earnings gains remain much smaller for females.

[25] An alternative approach would be to study differential effects by adding interaction terms of import/export exposure with various individual characteristics. This approach yields qualitatively similar insights as the sample split strategy pursued in this Section.

Table 5: **Effects by age**

[A] Younger than median of cohort (approx. 38yrs), N=634,443					
	(1)	(2)	(3)	(4)	(5)
import exposure	-0.0588***	-0.0595***	-0.0605***	-0.0375***	-0.0313***
	(0.0066)	(0.0069)	(0.0069)	(0.0042)	(0.0036)
export exposure	0.1532***	0.1602***	0.1597***	0.1223***	0.1148***
	(0.0240)	(0.0249)	(0.0252)	(0.0169)	(0.0147)
Fixed effects	i x p	i x j x r	i x j	i x r	i
[B] Older than median of cohort (approx. 38yrs), N=640,525					
	(1)	(2)	(3)	(4)	(5)
import exposure	-0.0255***	-0.0266***	-0.0278***	-0.0219***	-0.0193***
	(0.0039)	(0.0040)	(0.0041)	(0.0027)	(0.0025)
export exposure	0.0606***	0.0610***	0.0641***	0.0619***	0.0635***
	(0.0156)	(0.0162)	(0.0164)	(0.0117)	(0.0110)
Fixed effects	i x p	i x j x r	i x j	i x r	i

Notes: dependent variable in all specifications is 100 x annual earnings normalized by base year earnings. Same specifications as in Table 4. Sample divided by median age (38 years).

Table 6: **Effects by gender**

[A] Male, N=955,301					
	(1)	(2)	(3)	(4)	(5)
import exposure	-0.0282***	-0.0289***	-0.0302***	-0.0211***	-0.0181***
	(0.0053)	(0.0057)	(0.0057)	(0.0036)	(0.0030)
export exposure	0.1197***	0.1237***	0.1259***	0.0987***	0.0935***
	(0.0186)	(0.0197)	(0.0201)	(0.0139)	(0.0124)
Fixed effects	i x p	i x j x r	i x j	i x r	i
[B] Female, N=274,858					
	(1)	(2)	(3)	(4)	(5)
import exposure	-0.0247***	-0.0263***	-0.0266***	-0.0218***	-0.0204***
	(0.0040)	(0.0043)	(0.0043)	(0.0031)	(0.0029)
export exposure	0.0422***	0.0439***	0.0424***	0.0632***	0.0676***
	(0.0151)	(0.0160)	(0.0162)	(0.0132)	(0.0125)
Fixed effects	i x p	i x j x r	i x j	i x r	i

Notes: dependent variable in all specifications is 100 x annual earnings normalized by base year earnings. Same specifications as in Table 4. Sample divided by gender.

Those results add to a small but growing literature on the gender-specific effects of trade. Boler et al. (2015) document that exporting firms in Norway have higher gender wage gaps than non-exporters, and our results are broadly in line with that finding. In

Table 7: **Educational attainment**

	[A] Skilled, N=1,009,665				
	(1)	(2)	(3)	(4)	(5)
import exposure	-0.0436***	-0.0447***	-0.0457***	-0.0312***	-0.0264***
	(0.0052)	(0.0054)	(0.0055)	(0.0035)	(0.0030)
export exposure	0.1310***	0.1352***	0.1368***	0.1088***	0.1033***
	(0.0191)	(0.0201)	(0.0204)	(0.0142)	(0.0127)
Fixed effects	i x p	i x j x r	i x j	i x r	i
	[B] Unskilled, N=220,494				
	(1)	(2)	(3)	(4)	(5)
import exposure	-0.0196***	-0.0208***	-0.0220***	-0.0185***	-0.0194***
	(0.0045)	(0.0045)	(0.0045)	(0.0034)	(0.0032)
export exposure	0.0129	0.0158	0.0172	0.0382***	0.0477***
	(0.0189)	(0.0188)	(0.0188)	(0.0142)	(0.0137)
Fixed effects	i x p	i x j x r	i x j	i x r	i

Notes: dependent variable in all specifications is 100 x annual earnings normalized by base year earnings. Same specifications as in Table 4. Sample divided by two educational groups. Skilled workers have university degree, vocational training, or advanced high school degree. Unskilled workers have lower secondary education or less.

particular, as export exposure increases, the gender wage gap seems to widen within firms, at least for those matches that are not broken off. Furthermore, Card et al. (2015) find that increases in firm revenue dis-proportionally benefit earnings for men in Portugal, thereby contributing to the gender wage gap. Our results point into the same direction, as rising exports are one important channel for revenue expansions of firms.

5.3 Education

There is a large literature in international economics on how trade affects inequality between and within skill groups. In Table 7 we first approach the between-component, and split the sample into two broad groups according to formal educational attainment. Workers are defined as skilled if they have completed vocational training, hold an advanced-level high school degree (Abitur), or a university degree, and as unskilled when they have completed only lower secondary schooling or less.

It turns out that the adverse effects of import exposure are somewhat stronger for skilled than for unskilled workers, particularly within job spells. Yet, the main difference across skill groups is the much stronger export effect for the former. In fact, within job spells we find no evidence that unskilled manufacturing workers benefit from rising export opportunities, while skilled individuals gain substantially (see column 1). There is some evidence that unskilled workers sort into those industries (see column 5), but the total gains from rising export exposure remain less than half of what

we observe in the subsample of skilled workers. In effect, we may therefore conclude that rising trade exposure has fueled between-group earnings inequality in Germany. Yet, we would expect important inequality trends to arise *within* groups, since the two educational brackets are rather coarsely defined.

5.4 Unobservable skills and workplace characteristics

To address within-group inequality, we adopt the methodology of Abowd et al. (1999) who perform wage regressions with additive person and establishment-fixed effects on large linked employer-employee datasets. This approach has been recently applied to the German case by Card et al. (2013), who decompose wage inequality trends and find important contributions by unobservable worker and workplace characteristics.

Their approach starts from a standard wage regression with additive fixed effects, $ln\ (\text{wage}_{it}) = \alpha_i + \psi_{p(it)} + x'_{it} + r_{it}$, where observable worker characteristics x'_{it} include education-specific age and experience profiles. The person effects α_i can therefore be interpreted as unobservable worker skills that are rewarded equally across different employers, and which are orthogonal to educational attainment. Similarly, the establishment-fixed effects $\psi_{p(it)}$ are proportional pay premiums (or discounts) by plant p to all its employees. They may stem, for example, from rent-sharing or efficiency wage considerations, and serve as a proxy for workplace quality.[26]

To implement this approach, we obtain the fixed-effects estimates from Card et al. (2013), which are based on the universe of social security records in Germany and can be merged to our 15% sample via unique person and establishment identifiers. It is important to note that those fixed-effects are identified from time windows that *precede* the start of our two decades, since they would otherwise be endogenous to the later trade exposure trends.[27] We then split our data along the terciles of the person and the establishment fixed-effects distributions, in the latter case pertaining to the observed worker-plant matching in the respective base year, and then repeat our empirical estimations for each of those six subsamples. The results are reported in Table 8.

5.4.1 Unobservable worker skills

The left half pertains to the sample splits according to person effects. To save space, we only present the results for the $\gamma_{i,p}$-, the $\gamma_{i,j}$-, and the γ_i-model from now on.

Column 1 shows that, within job spells, rising import penetration hits good workers from the top tercile somewhat less than medium and bad workers from the two bottom terciles. Those differences are even more pronounced when we also exploit the variation between worker-establishment matches within and across industries (columns 2

[26]Those fixed effects should, however, not be interpreted literally as firm productivity (Eeckhout and Kircher; 2011) but rather as rent-sharing elasticities at the establishment level (Card et al.; 2016).

[27]For the first decade of our analysis, we use their estimated fixed effects from the 1985–1991 time interval, and for the second decade their estimates for the 1996–2002 period. We thank Joerg Heining for making these estimates available to us.

Table 8: **Worker ability and workplace quality**

	(1)	(2)	(3)	(1′)	(2′)	(3′)
	33% good workers (N=330,685)			**33% good workplaces** (N=326,140)		
import exposure	-0.0340**	-0.0353***	-0.0193***	-0.0308***	-0.0327***	-0.0196***
	(0.0056)	(0.0061)	(0.0034)	(0.0069)	(0.0075)	(0.0043)
export exposure	0.1265***	0.1350***	0.0958***	0.0750***	0.0796***	0.0588***
	(0.0216)	(0.0233)	(0.0150)	(0.0186)	(0.0202)	(0.0132)
	34% medium workers (N=320,960)			**34% medium workplaces** (N=317,227)		
import exposure	-0.0449***	-0.0463***	-0.0268***	-0.0345***	-0.0383***	-0.0190***
	(0.0052)	(0.0053)	(0.0031)	(0.0055)	(0.0060)	(0.0032)
export exposure	0.1245***	0.1269***	0.0952***	0.0810***	0.0956***	0.0712***
	(0.0188)	(0.0193)	(0.0128)	(0.0199)	(0.0212)	(0.0131)
	33% bad workers (N=320,960)			**33% bad workplaces** (N=316,896)		
import exposure	-0.0371***	-0.0389***	-0.0271***	-0.0414***	-0.0416***	-0.0278***
	(0.0199)	(0.0204)	(0.0130)	(0.0200)	(0.0204)	(0.0132)
export exposure	0.0753***	0.0779***	0.0738***	0.1182***	0.1168***	0.0992***
	(0.0199)	(0.0204)	(0.0130)	(0.0200)	(0.0203)	(0.0132)
Fixed effects	i x p	i x j	i	i x p	i x j	i

Notes: dependent variable in all specifications is 100 x annual earnings normalized by base year earnings. Same specifications as in Table 4. Sample divided by terciles of the distribution of pre-estimated Card et al. (2013) worker and firm fixed-effects.

and 3). Since those worker abilities are orthogonal to education, we may thus conclude that import penetration has increased within-group inequality, as it has disproportionally hit less able workers. For rising export opportunities we reach a similar conclusion that is quantitatively even stronger: there are positive earnings effects throughout, but those gains are 30–60% stronger in the top than in the bottom of the worker ability distribution, thereby also fueling inequality within skill groups.

In sum, the evidence in Tables 7 and 8 suggests that rising trade exposure with the East has increased earnings inequality both *between* and *within* skill groups in Germany. This diagnosis is consistent with the recent theory and empirical results for Brazil by Helpman et al. (2012), and recent comprehensive analyses of wage inequality in Germany by Card et al. (2013) and Felbermayr et al. (2014).

5.4.2 Unobservable workplace characteristics

Finally, we explore heterogeneity with respect to the establishment-fixed effects. In the right half of Table 8 we find that workers who start out in "bad" establishments are somewhat more adversely affected by import shocks than those who are initially employed in better workplaces. The differences are relatively small, however. For export exposure, we even find stronger positive effects in the subsample of employees who start out in "bad" establishments. This does not mean, however, that low-productive

firms benefit more from rising export opportunities, because these establishment effects need not capture firm productivity. The results rather suggest that rising export exposure has not led well-paying firms to increase their pay premiums even more, but that there was some mean reversion in firm-specific wage components because of export shocks. Stated yet differently, these firm components have apparently not added to the salient trend of within-group earnings inequality, but this trend is driven more strongly from the worker-specific wage components.

6 Push effects of import shocks: Event study approach

The short- and medium-run analyses have consistently shown that rising import penetration induces some workers to leave the exposed industries. However, we have not yet compared the earnings performance of movers relative to stayers. Who faces the greater cumulative earnings losses? Those who stay and are continuously exposed? Or those who move and thereby escape the rising import penetration, but possibly subject to disruptions and losses of specific human capital? And how do movers perform relative to stayers *before* the industry switch? In this final section we explore these questions with an event study approach in the spirit of Jacobson et al. (1993), which illustrates the *dynamics* of the typical individual job biography of industry-movers and stayers and sheds light on the nature of mobility responses induced by import shocks.

6.1 Methodology

We proceed as follows: We focus on the upper quartile of the distribution of net import exposure, and observe all workers who start in one of those strongly import-exposed industries j in the respective base year $t = 0$. Then we identify all workers who move to a different industry j' at some point between $t = 1$ and $t = 10$, and use propensity score matching methods to select for each worker in the treatment group a corresponding control group member among the stayers in the respective industry j with similar earnings, education, nationality, tenure, age, and the preceding identified ability level. More specifically on the latter, we require that treatment and control group member come from the same 5% bracket of the distribution of worker-specific wage components as identified from five years before the start of the observation period (see Section 5.4.1.). This ensures that we compare movers and stayers not only with similar observable characteristics, but also with similar unobserved ability. We then estimate the following model jointly for movers $M_i = 1$ and for stayers $S_i = 1$:

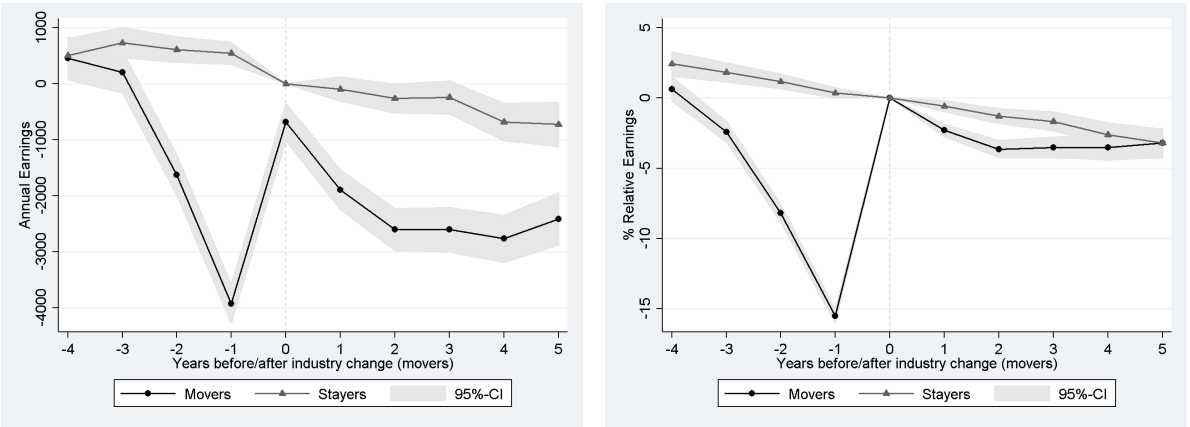
$$y_{ikt} = \alpha_i + \gamma_t + X'_{it}\beta + \sum_{k=-5}^{6} \delta_k^S S_i^k + \sum_{k=-5}^{6} \delta_k^M M_i^k + u_{ikt} \tag{4}$$

In equation (4), y_{ikt} are (normalized) annual earnings for worker i in calendar year t, k years before/after the "event" which happens at time $k = 0$ for the movers.[28] M_i^k and S_i^k are dummies for treatment and control group members, and the coefficients δ_k^M and δ_k^S reveal how earnings of movers and stayers evolve over time relative to the reference period $k = 0$.[29] Finally, X'_{it} are cubic age terms, γ_t are general year dummies, and α_i are individual fixed-effects. The latter pick up remaining unobservable time-invariant characteristics of movers and stayers, and when those dummies α_i are included, we identify how earnings of a given worker evolves relative to $k = 0$ but cannot directly compare movers and stayers in absolute terms. In another specification we also drop the α_i terms, which then allows for such a comparison.

6.2 The typical mover versus the typical stayer

Figure 3 depicts the results when we consider *all* movers out of the strongly import-exposed industries. Panel (a) shows the the specifications without, and panel (b) the one with worker-fixed effects α_i. Both approaches show a similar pattern, and we do not find significant absolute earnings differences at the beginning of the pre-event period at $k = -4$ in panel (a). This is reassuring that the control group members are indeed closely matched to their respective counterparts in the treatment group.

Figure 3: **Event study (top-25 % net import exp.) – Movers versus stayers**



(a) Without worker-FE: All movers

(b) With worker-FE: All movers

Notes: The figures display the coefficients of separate time-to-event dummies for industry movers and stayers from regressions of (normalized) annual earnings. The sample consists of 41,298 workers who started in highly import competing industries but left in the following 10 year period and the same number of matched stayers. Further covariates in panel (a) are calendar year fixed effects, a cubic age polynomial, and dummies for gender, educational attainment, nationality. Further covariates in panel (b) are calendar year fixed effects, a cubic age polynomial, and worker fixed effects.

[28] For the stayers, who do not face an actual "event", we assign an artificial event date according to their nearest neighbor to estimate δ_k^S.

[29] All observations more than four years before the event are "binned" into a single dummy, and so are all observations more than five years afterwards.

Inspecting the earnings profiles shown in Figure 3, we can see that the typical mover and stayer both experience earnings declines prior to the "event", which reflects their affiliation in import-exposed sectors. This decline in the pre-event period is much sharper for the later movers, however. When the event occurs, we see that movers experience an upward earnings jump from period -1 to period 0. This suggests that the industry switch is associated with a preceding unemployment spell in the typical employment biography: movers often tend to be unemployed in -1, and then take up a new job in a different industry at time 0.[30] In the post-event period, we observe that the earnings profile of the typical mover at first declines again, but then eventually flattens out. This is different for the typical stayer, for whom the continuous earnings decline goes on. However, despite this stabilization, the typical mover is *not* able to make up for the cumulated earnings losses from the pre-event period, and performs worse than the typical stayer not only before but also after the move.

One possible explanation for the dynamics revealed in Figure 3 is that the industry switch for the typical mover is not voluntary but "forced" after a job loss or layoff, and that this push out of the industry leads to a depletion of specific human capital.[31] This typical mover undergoes an unemployment spell first, and then never catches up to previous earnings levels in the new jobs, which often tend to be outside of manufacturing. Moreover, the observed flattening in Figure 3 is also consistent with our result from Table 4 that workers can mitigate the marginal impact of import shocks by industry mobility. Indeed, one reason why the typical mover does not experience further earnings declines after a while may be that this worker is no longer strongly import-exposed. Still, this typical mover is left with a cumulative loss relative to the typical stayer for whom the continuous decline continues.

6.3 Steady workers and movers with varying ability

While Figure 3 shows the typical pattern across all workers from strongly import-penetrated sectors, we also perform an analogous event study for the subsample of workers with no unemployment spells whatsoever. In panel (a) of Figure 4 we compare the earnings profile of the typical mover and stayer among the steady workers who start out in those industries, and we find very different dynamics than before.

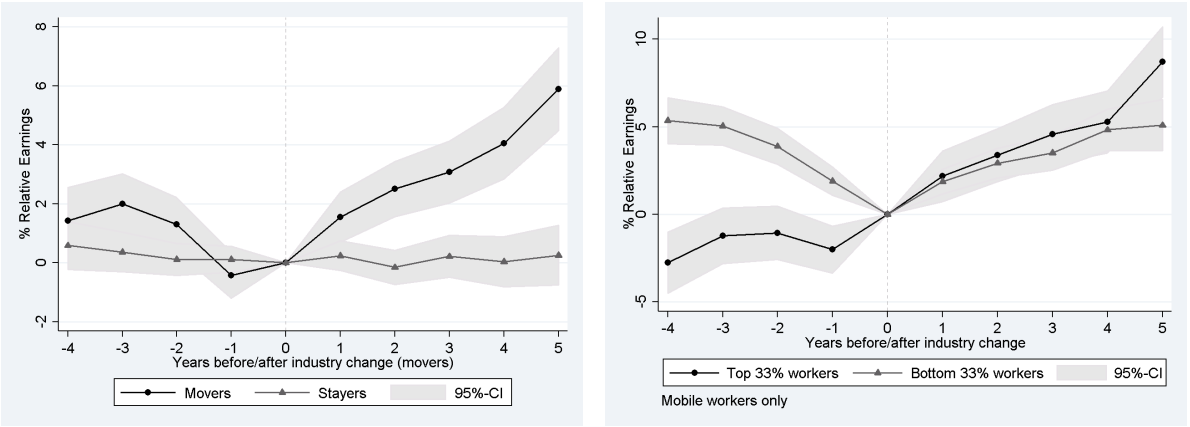
Indeed, the biographies of smooth movers and stayers behave similarly in the pre-event period, and by construction there are no slumps caused by unemployment spells. But after the industry switch we observe that the movers perform significantly better in their new jobs than the stayers who remain in the strongly import-competing jobs. Movers even realize a cumulative earnings gains, while stayers are left with

[30] Recall that we define displaced workers to be still affiliated with their original industry until they take up another job elsewhere (which happens at time 0 for the movers).

[31] To be sure, our administrative data do not allow us to identify the precise individual motives for a mobility decision. The adjectives "involuntary" or "forced" therefore have be taken with a grain of salt, as we only conjecture them from the underlying typical job biographies.

slight losses. This picture is, thus, consistent with panel E of Table 3 and provides an explanation why there is no overall cumulative earnings loss from import-shocks to the original industry among the steady workers: because the movers, who switch smoothly from one industry to the next, adapt very well in their new jobs.

Figure 4: **Event study (top-25 % net import exp.) – Only smooth biographies**



(a) With worker-FE: Movers versus stayers

(b) With worker-FEs: High/low ability movers

Notes: Specification as in Figure 3, panel (b). The sample in Panel (a) consists of 30,623 workers with smooth job biographies who started in highly import-competing industries. Panel (b) displays the coefficients of separate time-to-event dummies for workers in the top and bottom terciles of the distribution of pre-estimated Card et al. (2013) worker fixed-effects in a regression of normalized annual earnings. The sample consists of 13,761 workers with smooth job biographies who started in highly import competing industries but left in the following 10 year period.

Finally, in panel (b) we split the subsample of steady workers even further, and illustrate the profile of movers from the top and the bottom tercile of the preceding ability distribution. Recalling that earnings are expressed relative to the reference time $k = 0$ for each group, this panel reveals an interesting pattern: Both types of smooth movers experience earnings gains *after* the industry switch, which is consistent with panel (a). Yet, the movers with low ability have been on a downward trend in their old jobs prior to the industry switch, while the movers with high ability have been on an upward trend even before, which then accelerated after switching to another industry.

Overall, Figures 3 and 4 illustrate that mobility out of strongly import-exposed industries can take different forms, which in the terminology of the well-known Roy-model from the labor economics literature may be described as *selection on costs* versus *selection on returns*. Among all workers, the former pattern seems to be dominant: Industry mobility typically comes after a layoff, so that the costs of mobility are low, and is associated with medium-term losses. This type of induced mobility is, thus, not likely to reflect voluntary job sorting in response to exogenous changes in trade exposure. Those workers rather seem to be "pushed out" of their jobs by the import shocks, and later on perform worse than their former colleagues who manage to keep their old jobs in the import-penetrated industries. Yet, there is considerable heterogeneity in the

data, and within particular subgroups in the labor market, we also observe another pattern of mobility responses. Here, in the wake of trade shocks, we observe that some highly able and steady workers select themselves out of import-competing industries, supposedly voluntarily, and into different industries where they henceforth perform well, and substantially better than their counterparts who did not escape the import-competing sectors. In short, workers with high ability seem to adjust rather differently to exogenous trade shocks than manufacturing workers at large.

7 Conclusions

In this paper, we shed light on how manufacturing workers in Germany were affected by, and adjusted to, the rising trade exposure from China and Eastern Europe between 1990 and 2010. We use detailed spell data which allow us to follow single workers over time, and we consider a variety of empirical approaches that exploit the rich variation within and across worker-establishment matches. Moreover, we illustrate the impact of trade shocks in individual work biographies with an event study approach that compares stayers and movers out of highly import-exposed industries.

Our key insights are that German manufacturing workers benefited at large from this particular globalization episode, but there have been winners and losers. For workers of strongly import-competing sectors, we find substantial earnings losses in the short- and in the medium-term. Moreover, we observe an *asymmetry* in the response to rising trade exposure. There are notable "push effects" out of sectors with high import penetration, but only relatively weak "pull effects" into expanding export-oriented manufacturing industries. Indeed, many workers who are "pushed out" of their manufacturing jobs by trade end up in the service sector, often after a temporary unemployment spell, and are stuck with lower wages in the medium-term. The earnings gains from rising export opportunities, by contrast, seem to accrue mainly within the respective sectors, both on-the-job and via wage increasing intra-industry reallocations of workers across establishments. Yet, those industries with rising export opportunities do not seem to attract workers from the declining import-competing sectors. Summing up, we find that individual earnings inequality in Germany has increased due to trade along various dimensions, not only in general but also within and across particular groups in the labor market.

Our study may be informative for a recently growing literature that explores the impact of external trade shocks on the adjustments of heterogeneous workers across industries, regions, and firms in quantitative general equilibrium models of international trade. Some of these papers even consider the rise of China as the specific trade shock whose consequences are then simulated in counterfactual analyses. See, in particular, the recent studies by Caliendo et al. (2015), Galle et al. (2015) and Fan (2015). The reduced-form empirical results in our study are complimentary to this research agenda, because we explore how workers have *actually* adjusted to globalization, and

the structural trade literature may find the patterns that we uncover from the data as a useful source for model identification or validation.

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Appendix

A Trade exposure including downstream linkages

In our main specifications, we only consider how workers are affected by imports and exports of their own industry's imports and exports. However, if an industry suffers from import competition, it might also reduce demand from its domestic suppliers, whereas it might increase this demand when it exports more. We thus extend our trade measure to account for these linkages.

We use the 1995 input-output table from the German Statistical Office to calculate what share of its output an industry sells to each other industry. This table contains information on linkages between 69 2-digit industries. We can expand this matrix to our 221 3-digit industries under the assumption that each industry causes linkages that are proportional to its size. We therefore first duplicate all rows and columns of the 2-digit table to the number of 3-digit industries they include. Then we multiply each element of this matrix by the employment share of the corresponding 3-digit industry in its 2-digit industry and obtain a 221×221 matrix. Finally, we use the Kronecker product of this matrix and an $T \times T$ identity matrix to get a matrix W that reflects the downstream linkages of all industries in all years of our dataset.

Multiplying W by the $J \times T$ vectors of trade exposures ImE or ExE from equation 1 would yield the additional exposure an industry receives from its direct buyers. We follow Acemoglu et al. (2016) and compute the Leontief inverse of the input-output matrix to account for the additional exposure of the whole value chain. Our augmented measures for trade exposure are then defined as $ImE_{+down} = ((I - W)^{-1})'ImE$ and $ExE_{+down} = ((I - W)^{-1})'ExE$. These capture both the direct effects of the own industry's exposure as well as the weighted indirect effects of all downstream industries.

B The estimation approach with gravity residuals

In our baseline specifications we use an instrumental variables strategy that is well established in the related literature. However, one caveat of this approach is that the exclusion restriction would be violated if trade between the East and the countries we use to construct our instrumental variables is correlated with domestic German shocks. While we believe that this correlation is negligible, it cannot completely ruled out as practically everything is related in general equilibrium. As a robustness check, we therefore adapt an approach based on a gravity model of trade which was introduced as a robustness check in Autor et al. (2013) and was also employed in Dauth et al. (2014).

The basic idea of this approach is that one derive expressions for the East's exports in industry j to any country k and Germany's exports to the same country from a standard gravity equation à la Anderson and van Wincoop (2003). Taking logs and

subtracting both terms shows that the relative exports from the East and Germany to the same country are a function of the East's comparative advantage in industry j (relative to Germany) and the relative accessibility of this country.[32]

Using bilateral trade data, we can represent this in the following regression equation:

$$ln(EX_{jt}^{EAST \to k}) - ln(EX_{jt}^{D \to k}) = \phi_j + \phi_k + \mu_{jtk}, \tag{A.5}$$

where ϕ_j and ϕ_k are industry and destination country fixed effects. The former absorbs the mean comparative advantage in industry j while the latter captures the differential accessibility of country k. Estimating this model for a panel, we obtain the average residual for industry i at time t across importers. Taking ten year differences, $exp(\overline{\mu}_{jt+10}) - exp(\overline{\mu}_{jt})$ can be interpreted as an increase of the comparative advantage of the East relative to Germany in producing industry j's goods.

In addition, we run an analogous regression of Germany's exports of industry j's goods to the East relative to its exports to other countries:

$$ln(EX_{jt}^{D \to EAST}) - ln(EX_{jt}^{D \to k}) = \phi_j + \phi_k + \pi_{jtk} \tag{A.6}$$

Again averaging the residual across importers and taking ten year differences, we obtain $exp(\overline{\pi}_{jt+10}) - exp(\overline{\pi}_{jt})$. This reflects the East's importance as a destination for German exports of industry j's goods in year t relative to all other countries.

Taken together, these two measures represent the change in relative comparative advantage and import demand of the East vis à vis Germany. We can use them to compute the predicted increase in Germany's net export exposure (but not distinguish between exports and imports):

$$\Delta NetE_{jt}^{gravity} = \frac{(EX_{jt}^{D \to EAST} - IM_{jt}^{EAST \to D}) \cdot \left[exp(\overline{\pi}_{j(t+10)}) - exp(\overline{\pi}_{jt}) - [exp(\overline{\mu}_{j(t+10)}) - exp(\overline{\mu}_{jt})]\right]}{\overline{w}_{j(t-10)} L_{j(t-10)}} \tag{A.7}$$

Table A.1 displays the predicted 10-year change of both the net export exposure from our standard trade measures and from the gravity approach.

[32] See the online appendices of Autor et al. (2013) and Dauth et al. (2014) for details of this derivation.

C Appendix Tables

Table A.1: **Summary statistics of net trade exposure**

	mean	sd	1st quartile	median	3rd quartile
1990-2000					
Δ net export exposure	-0.028	0.296	-0.113	0.006	0.099
Δ net export exposure (gravity)	0.867	5.542	-0.603	0.136	1.070
2000-2010					
Δ net export exposure	0.071	0.641	-0.004	0.155	0.342
Δ net export exposure (gravity)	1.152	9.122	-0.439	0.327	2.702

Table A.2: **Include workers who changed into the manufacturing sector but started elsewhere**; Treat trade exposure in non-manufacturing as zero

2SLS	(1)	(2)	(3)	(4)	(5)
import exposure	-0.0403***	-0.0412***	-0.0415***	-0.0291***	-0.0248***
	(0.0047)	(0.0049)	(0.0049)	(0.0031)	(0.0028)
export exposure	0.1077***	0.1111***	0.1125***	0.0950***	0.0923***
	(0.0180)	(0.0188)	(0.0191)	(0.0131)	(0.0122)
Fixed effects	i x p	i x j x r	i x j	i x r	i
Groups	1949340	1855001	1794957	1607466	1350974
R^2	0.640	0.634	0.625	0.604	0.564
KP	61.330	54.783	54.953	75.797	81.719

Notes: Same specifications as in table 4. Sample includes 1,350,974 workers who started in any sector but were ever employed in manufacturing during the decade.

Table A.3: **Include trade exposure of downstream industries** – Only workers who start in manufacturing

2SLS	(1)	(2)	(3)	(4)	(5)
import exposure	-0.0362***	-0.0369***	-0.0380***	-0.0268***	-0.0234***
	(0.0048)	(0.0050)	(0.0051)	(0.0033)	(0.0030)
export exposure	0.1053***	0.1079***	0.1106***	0.0941***	0.0942***
	(0.0174)	(0.0184)	(0.0188)	(0.0128)	(0.0116)
Fixed effects	i x p	i x j x r	i x j	i x r	i
Groups	1686734	1598380	1547363	1413779	1230159
R^2	0.628	0.622	0.614	0.599	0.570
KP	74.459	65.455	65.574	93.624	107.837

Notes: Number of workers: 1,230,159. Same specifications as in table 4. Import exposure and export exposure include exposure of downstream industries, weighted by IO-linkages.

Table A.4: **Include workers who changed into the manufacturing sector but started elsewhere**; Include trade exposure of downstream industries

2SLS	(1)	(2)	(3)	(4)	(5)
import exposure	-0.0364***	-0.0369***	-0.0373***	-0.0266***	-0.0226***
	(0.0048)	(0.0050)	(0.0050)	(0.0032)	(0.0028)
export exposure	0.1087***	0.1108***	0.1130***	0.0960***	0.0949***
	(0.0172)	(0.0182)	(0.0186)	(0.0125)	(0.0115)
Fixed effects	i x p	i x j x r	i x j	i x r	i
Groups	1949340	1855001	1794957	1607466	1350974
R^2	0.640	0.634	0.625	0.604	0.564
KP	75.335	66.374	66.615	92.465	100.311

Notes: Same specifications as in table 4. Sample includes 1,350,974 workers who started in any sector but were ever employed in manufacturing during the decade. Import exposure and export exposure include exposure of downstream industries, weighted by IO-linkages.

Table A.5: **Only Western German Workers**

2SLS	(1)	(2)	(3)	(4)	(5)
import exposure	-0.0400***	-0.0408***	-0.0420***	-0.0297***	-0.0255***
	(0.0048)	(0.0050)	(0.0050)	(0.0033)	(0.0029)
export exposure	0.0995***	0.1015***	0.1025***	0.0873***	0.0853***
	(0.0178)	(0.0183)	(0.0186)	(0.0131)	(0.0120)
Fixed effects	i x p	i x j x r	i x j	i x r	i
Groups	1561213	1480326	1433552	1313222	1144278
R^2	0.629	0.622	0.614	0.600	0.571
KP	63.264	57.277	57.481	78.141	90.029

Notes: East German Workers starting in 2000 excluded from sample. Number of workers 1,144,278. Same specifications as in table 4.