Imports, Exports and Income Risk[1]

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Abstract

This paper undertakes a detailed empirical analysis of the association between trade and labor income risk in Germany, over the period 1976-2012. We use longitudinal data on workers, detailing their full employment histories, to estimate the magnitude of idiosyncratic income risk that workers experience. In estimating risk, we take into account the evolution of human capital of individual workers and the heterogeneous risk that different cohorts face in the labor market. We study next the causal role of trade in explaining the variation in income risk across different cohorts of workers, employed in different sectors and regions, and find trade to have statistically and quantitatively significant effects on persistent income risk. We find imports to increase risk and exports to decrease risk at both the sectoral and regional level of analysis, suggesting that it is sectoral and regional trade imbalances that drive income risk, on net.

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1. Introduction

International trade in goods and services brings important economic benefits – productive resources are allocated more efficiently towards the production of those goods in which a country has comparative advantage and consumers get access to a greater variety of goods produced at lower prices abroad. While the benefits of trade are well understood, it is also true that trade openness may cause reallocation of workers across different sectors of production and across different firms within a sector -- and that this process may not be an orderly or costless one. Underlying much of the public concern regarding globalization lies this apprehension that greater trade may expose workers to a riskier environment, with the possibility of displacement, income losses and unemployment.

Theoretically, there are multiple mechanisms through which trade may impact the volatility of individual incomes. On the one hand, firms in import competing sectors that experience greater import competition may respond by cutting back their output and employment of labor; workers will be exposed to risk if the displacement of workers results in unpredictable and heterogeneous outcomes (Melitz, 2003). On the other hand, firms in exporting sectors may increase their output and labor demand, thereby creating additional job opportunities, accommodating workers displaced elsewhere and decreasing risk. Depending on the industrial structure, with international trade, some firms in both import competing and exporting sectors may get bigger while others get smaller -- leading to yet other possibilities that may increase or decrease risk for workers as they are reallocated across firms within sectors.

Whether risk indeed rises for workers with trade and what the quantitative effects would be for different sectors and different types of workers constitute the set of empirical questions that motivate this paper. Here we undertake a detailed empirical analysis of the association between trade and labor income risk in the Germany using worker level data from the Institute for Employment Research (IAB), spanning the 1976-2012 period. To estimate labor income risk, defined as the variance of unpredictable changes in earnings, we employ specifications of the labor income process that distinguish between transitory and persistent shocks to income. This distinction is important as the former can be smoothed using self-insurance, while the later cannot and will thus have larger welfare consequences.

In our analysis, we combine industry-level (and separately regional-level) time-varying estimates of the persistent component of labor income risk with measures of industry (and regional) exposure to international trade to estimate the relationship between labor income risk and trade. The longitudinal richness of the data - with workers followed for the duration of their labor market experience- allows us to control for a variety of issues that have bedeviled earlier studies. Given that labor income risk varies with age (in a potentially non-monotonic manner) and that different cohorts of workers may experience different entry-year effects, controlling for the heterogeneity in the composition of the work force across sectors and over time can be crucial. We account for this by estimating time-varying risk separately for different entry cohorts in different industries and regions. Further, since we have extremely detailed information on workers' labor market biographies, we are able to construct measures of the firm, occupation and industry tenure of workers and then account for the human capital of workers in estimating the income risk they face.

Our empirical results for Germany can be summarized as follows. First, in estimating labor income risk, we find that income risk is non-monotonically related to age. That is, risk first declines with age and then rises (as in the findings of Feigenbaum and Li, 2012). We also find that different cohorts experience quite different levels of risk in their initial years in the labor market. Taken together, these findings amply justify our cohort-level approach to estimating risk. Second, we find that within-industry and within-region changes in import (per worker) and exports (per worker) are strongly and causally related to income risk. Imports increase risk and exports decrease risk and do so in an economically significant manner. Higher levels of imports result in higher level of risk, whereas higher exports result in lower level of risk. Specifically, the mean increase in imports per worker between 2000 and 2007 results in a 6% increase in income risk while the mean increase in exports per worker leads to a decline in income risk of about 5%. Finally, the result that, in general, the increase in income risk due to rise in imports within a region is negated by decreased risk due to a rise in exports within that region raises the interesting possibility that diversified regions with both importing and exporting industries may offset risk due to rising imports by lowering risk through rising exports, thus, at least partially, insuring workers who live in these regions. Thus, the geographic location of production will play an important role in determining the overall impact of trade on income risk.

This paper contributes to the literature on individual income volatility (Gottschalk and Moffitt, 1994; Carroll and Samwick, 1997; Hryshko, 2012; Carey and Shore, 2013). Based on the estimation technique as in Meghir and Pistaferri (2004), we exploit the unique cohort structure of our data and thus uncover a series of stylized facts concerning the age profile and the dynamic evolution of income risk. The rich information from worker biographies further enables us to control a large set of observables, measures of specific human capital in particular, in our risk estimation. The resulting risk estimates at both the industry and regional level improve upon the earlier work (Krebs and Yao, 2016) that focuses on income risk at the aggregate level, thus providing a more complete picture of individual income volatility in Germany.

This paper adds to the growing discussion on the nexus between trade and income risk. A large literature studies the labor market effects of international trade by examining its impact on the *level* of earnings or employment (Autor, et al., 2013; Dauth, et al., 2014, 2019; Acemoglu, et al., 2016; Pierce and Schott, 2016). However, what receives less attention but is perhaps more complex is the second-moment effects of trade: how trade impacts income risk. Using the individual survey data, Krishna and Senses (2014) provide the first set of evidence on the causal relationship between trade and income risk in the US. This paper refines the income estimates using the administrative data and offers, to our knowledge, the first systematic investigation in Germany. [2]

The rest of the paper is structured as follows. We describe the worker-level and trade data in Section 2. In Section 3, we present the econometric framework of income risk estimation. The main estimation results are presented in Section 4. We conclude in Section 5.

2. Data

We estimate risk using the German worker-level data from the Institute for Employment Research (IAB) spanning the 1976-2012 period. The employee-employer linked data provides very detailed information on a wide array of worker and job characteristics and some information on employer characteristics.

For the current analysis, we restrict our sample to include only men who are not in school during the sample period. To avoid complication that arises from the transition period following the fall of the

[2] Hogrefe and Yao (2016) document a negative impact of offshoring on income risk using the German worker-level data.

iron curtain, we further restrict to our sample to west German workers. We draw full employment histories for 16 entry cohorts from 1976 to 2006 (using even entry year cohorts) and construct non-overlapping panels over which we estimate risk. Our benchmark estimates of risk are estimated over five panels spanning six years: 1983-88, 1989-94, 1995-2000, 2001-06 and 2007-12. Due to the cohort structure of the dataset, the earlier panels consist mostly of younger workers with fewer years of experience. For instance, the 1983-88 panel includes the full population of men who entered the labor market in 1976, 1978, 1980 and 1982, with maximum labor market experience of 7 years at the beginning of the panel, while the 2007-12 panel includes workers who entered the labor market 31 years prior to the beginning of the panel, as well as workers who entered only 1 year prior. The regional and industry coverage of the data is substantial, allowing us to estimate risk for workers employed in 325 districts in former West Germany and for workers employed in 92 manufacturing industries (3-digit NACE rev. 1.0).

Our bilateral trade data is from the UN Comtrade database. The original data is at SITC Rev. 2 5-digit level prior to 1988 and SITC Rev. 3 5-digit level from 1988 onwards. We use the concordance tables from the World Bank and UN Statistics to convert and harmonize the data. The final trade data is organized at the NACE Rev.1 3-digit level, which is the same as the WZ 93 industry classification adopted in our worker-level data. Following Dauth et al. (2014) and Helm (2019), we drop mining and fuel industries. The trade volumes are deflated using the CPI series from DESTATIS and converted to the 2005 Euros.

3. Estimation of Income Risk

The detailed information on worker characteristics contained in our data set permits separate estimation of income risk for different worker groupings. For instance, we can estimate income risk for workers in different industries and, separately, for workers in different regions in the country. In addition, to account for labor market entry-year effects and to allow for heterogenous risk profiles over worker's lifetime, we can estimate risk separately for workers in different entry-year cohorts.

In our analysis, we explore the links between industry trade exposure and risk as well as regional trade exposure and risk, using both cross sectional and time series variation in the data. With this in mind, we estimate risk as follows: For industry-analysis, for each of the five consecutive 6-year panels indicated above, we estimate the parameters characterizing income risk belonging to different industries assigned as of the beginning of each panel. The income risk is estimated using the pooled sample that consists of individuals in different entry-year cohorts and by entry-year cohort. Similarly, for the regional analysis, we estimate the parameters characterizing income risk separately for individuals in different entry-year cohorts and working in different regions. Thus, for any entry cohort in a given industry (or, alternately, a given region) income risk parameters are assumed to be constant within a panel but vary across panels.

In what follows, we outline a general approach to estimating income risk, given panel data on individual income in any given industry *i*. We discuss subsequently the exact method we use to analogously estimate risk for workers in different regions *r*. For notational simplicity, we do not discuss (pooled) entry cohorts or panels at this stage, but simply describe estimation of risk during the time-period spanned by a given panel, for a given grouping of workers.

We assume that the log of labor income of individual *i* employed in industry *j* in year t is given by:

$$y_{ijt} = \alpha_j + \alpha_t + \alpha_{r(i)} + \alpha_{o(i)} + \beta_j x_{ijt} + u_{ijt} \quad (1)$$

In (1), the labor income is defined as the quarterly earnings of the main ordinary job (in the event of multiple jobs, the highest-paying job); α_j, α_t, $\alpha_{r(i)}$, and $\alpha_{o(i)}$ denote the industry, time, region, and occupation fixed effects respectively with industry, region, and occupation being as of the beginning of each panel and β_j denotes industry specific returns to time varying worker characteristics represented by x_{ijt}, which is a vector of observable characteristics. We consider two sets of observables for x_{ijt} in the actual implementation of risk estimation. In the baseline setting, we adopt a parsimonious specification to include only age and age-squared. We also consider an alternative specification which includes a wide range of worker-specific characteristics constructed from the worker biographies. In particular, x_{ijt} consists of beginning-of-panel education,[3] experience, experience-squared, industry, occupation, and firm tenure. Moreover, to account for task components in wage determination, we include a task tenure measure as in Gathmann and Schönberg (2010) and

[3] The education variable is missing for a substantial fraction of observations. We use the imputed education variable as in Fitzenberger, et al. (2006).

a task-based centrality measure which is defined as the average distance between the cumulative task profile and each occupation in the economy. It turns out the two specifications yield remarkably similar risk estimates.

The residual in (1) is the stochastic component, u_{ijt}, which represents variation in individual income that cannot be explained by variation in returns to observable worker characteristics.

u_{ijt} is itself assumed to be the sum of two unobservable components, a persistent component ω_{ijt} and a transitory component η_{ijt}:

$$u_{ijt} = \omega_{ijt} + \eta_{ijt} \qquad (2)$$

We assume that persistent component ω_{ijt} follows a random walk, so that these shocks to income are fully permanent:

$$\omega_{ijt+1} = \omega_{ijt} + \varepsilon_{ijt+1} \quad (3)$$

where the innovation terms ε_{ijt} are independently distributed over time and identically distributed across individuals, with $\varepsilon_{ijt} \sim N(0, \sigma_{\varepsilon j}^2)$. Transitory shocks have no persistence at all and the random variables η_{ijt} are independently distributed over time and identically distributed across individuals, $\eta_{ijt} \sim N(0, \sigma_{\eta j}^2)$. $\sigma_{\epsilon j}^2$ and $\sigma_{\eta j}^2$ measure the magnitudes of permanent and transitory income risk in industry *j*. We finally note that the estimation of these income risk parameters, $\sigma_{\epsilon j}^2$ and $\sigma_{\eta j}^2$, assumes that these parameters are constant for workers in each entry-year cohort *c*, within a given time panel *p*, and in a given industry but vary across cohorts and across industries within each time panel as well as across time panels.

To filter out shocks to income with duration greater than a single period (see, for example, Meghir and Pistaferri (2004)), but that are not permanent (i.e., medium-run shocks falling somewhere between the temporary-permanent system described above), we allow, in our income specification, some moving average terms:

$$u_{ijt} = \omega_{ijt} + \sum_{k=0}^{K} \theta_{ijt-k} \quad (4)$$

with K indicating the maximum duration of any moving average term θ. In addition to the benchmark specification where transitory shocks to income have no persistence at all ($K = 0$), we consider two alternative specifications of the labor income process that allow for transitory shocks that last up to a year ($K = 4$, as the worker-level data is organized at the quarterly level) and, separately, up to two years ($K = 8$).

Under our income specification, as Carroll and Samwick (1997) have shown, the cross-sectional variance in residual income changes across individuals subject to the same shock over an *n* period time difference ($n > K$) can be written as:

$$Var[\Delta_n u_{ijt}] = 2\,\sigma_{\eta j}^2 + n\,\sigma_{\varepsilon j}^2 \quad (5)$$

Thus, the permanent income risk parameter $\sigma_{\varepsilon j}^2$ is simply the slope of the linear relationship between the cross-sectional variance of residual income changes and the time-period over which this income difference is considered. The key to identification is the fact that as we consider longer income differences, the transitory shocks disappear, while the persistent shocks cumulate. Equation (5) permits estimation of income risk parameters separately for workers in each entry cohort and in each industry for any panel. The cohort level analysis is motivated by two findings in the literature. First, income risk is documented to be a U-shaped function of age, with risk declining with age initially and slightly rising towards the end (Feigenbaum and Li, 2012). Second, year of entry in the job market affects both the initial level and dispersion of incomes across individuals (Kahn, 2010 and Altonji et. al., 2016).

As indicated earlier, in addition to industry of employment, our data set also indicates the district in which the worker is employed. Correspondingly, we also use (5) to estimate risk separately for each entry year cohort in each panel and district.

Estimates of Income Risk

Table 1 reports the estimates of individual income risk, $\sigma_{\epsilon j}^2$, with risk estimated at the industry and regional (district) level separately. The sample of each panel consists of entry cohorts that entered the labor market prior to the beginning of the panel. Specifically, Table 1 reports the mean and standard deviation of the risk estimates across different entry cohorts and 92 manufacturing industries (3-digit NACE level), separately for each panel. Permanent component of risk is estimated by filtering out transitory shocks of duration 1 year (K=4) and 2 years (K=8). Table 2 provides the corresponding estimates at the district level. Note that due to the entry of successive cohorts of workers over time, there is an increase in the number of workers in each panel over time. Note further that, in Table 2, the number of workers at the regional level, in any given year, is greater than the corresponding number of workers in industries in Table 1. This is because, for the district level analysis, we consider workers within and outside manufacturing while for the industry estimates, we focus solely on manufacturing workers. Note that, on average, risk estimates reported in Table 1 for the manufacturing sector is lower than those reported in Table 2, reflecting the higher volatility of the service sector.

Quantitatively, the estimates of risk presented in Table 1 are in the ballpark compared with other estimates in the literature. Consider, for instance, the mean value of the industry-level risk estimates over 1995-2000, of 0.0022. This corresponds to a quarterly standard deviation of log income changes of 0.047 and an annualized standard deviation of 0.094, which is about half of the income risk estimated using the SIPP panels of the US (Krishna and Senses, 2014). When we filter out shocks of longer duration, the permanent component of risk, on average, is slightly lower.

The mean of industry income risk as well as the mean of regional income risk appears to be declining over time. We note that while this could reflect overall trends in the economy, it also may be due to the changing age-composition of the worker sample across panels: Earlier panels include only younger workers and risk may vary systematically over a worker's lifetime. Tables 3 and 4 plot age-evolution of risk for six cohorts in our sample. Consider first the cohort that has 6 years of experience by 1988 (the 1982 cohort). This cohort then has 12 years of labor market experience by the end of the next panel in 1994; 18 years by 2000; 24 years of experience by 2006 and 30 years of experience by 2012. Mean industry risk (i.e., averaging across industries) declines from 0.0063 in 1983-88 to 0.0027 in 1989-94 to 0.0016 in 1995-2000 and stays around 0.0016 in 2001-06 and then further drops to 0.0011 during the last panel. The 1976 entry-cohort with 6 more years in the labor market (with 12 years of experience in 1983-88) experiences a similarly evolution of risk with age, with risk steadily declining from 0.0023 in 1983-88 to 0.0013 in 1995-2000, rising to 0.0017 over 2000-06 and then declining again over 2007-12, which suggests a non-monotonic relationship between risk and age.

Similarly, during a given panel, say 2007-2012, risk evolves in a non-monotonic fashion with age, falling from 0.0048 for the youngest cohort (with 6 years of labor market experience) to 0.0011 for the cohort with 30 years of labor market experience and then rising again to 0.0013 in the last career stage (36 years).

Also note that there is substantial variation in income risk across individuals, depending on when they entered the labor market. This is especially the case earlier in the career, with risk varying between 0.0048 in 2007-12 panel and 0.0088 in 2001-06 panel, for workers with 6 years of experience.

Table 4 provides the mean and standard deviations across districts and entry cohorts by each panel. The same patterns we demonstrated for the industry level estimates regarding risk over the life cycle and the importance of entry year are evident here as well. Once again, the non-monotonic pattern with risk first diminishing with age, then rising, and eventually diminishing over the 2007-12 panel emerges. For instance, for the 1976 entry cohort that 12 years of experience in 1983, risk is 0.0021 in the 1983-88 period. This declines to 0.0013 by 1995-2000, then rises to 0.0015 over 2001-06 and declines again to 0.0012 over 2007-12.

Summary statistics reported in Tables 3 and 4 together underscore the differences and systematic evolution of risk for different age cohorts and thus provide strong support for the use cohort-level analysis to analyze risk and its relationship with trade.

4. Trade and Income Risk

Next step is to estimate a causal relationship between trade exposure and individual income risk, by exploiting exogenous variation in German imports from and exports to Eastern Europe and China ("East") as in Dauth et. al. (2014). We conduct this analysis both at the industry level and at the local labor market level.

Industry Level Analysis

To study the link between trade and risk, we regress the permanent component of income risk estimated in Section 3 for each industry, panel and entry cohort on corresponding imports-per-worker (MPW) and exports-per-worker (EPW) in a specification that include an array of fixed effects and industry specific time trends. Our most general specification is:

$$\log\sigma^2_{\varepsilon jpc} = \alpha_0 + \alpha_M \cdot MPW_{jp} + \alpha_E \cdot EPW_{jp} + \alpha_j + \alpha_p + \alpha_c + \delta_j t + v_{jcp} \qquad (6)$$

Where $\sigma^2_{\varepsilon jpc}$ is the estimated permanent component of risk for industry *j,* estimated over panel *p,* for entry cohort *c.* α_j and α_c are industry and cohort fixed effects respectively, which are included to control for any time invariant industry-specific and cohort-specific factors that may affect the riskiness of earnings. α_p denotes panel-fixed effects and is included to control for any changes in macroeconomic conditions that affect the level of income risk across all industries within a panel. In addition, $\delta_j \times t$ captures any industry-specific time trends.

MPW_{jp} and EPW_{jp} measure imports per worker from the East (Eastern Europe and China) and exports per worker to the East (Eastern Europe and China), respectively for industry *j* and panel *p,* and are calculated as[4]:

$$MPW_{jp} = \frac{Import_{jp}^{Germany \leftarrow East}}{L_{jp}}$$

$$EPW_{jp} = \frac{Export_{jp}^{Germany \rightarrow East}}{L_{jp}} \qquad (7)$$

[4] Eastern Europe denotes the following countries in our analysis: 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.

where L_{jp} denotes the annual employment count in industry *j* in panel *p*.[5] In (6), the main coefficients of interest are α_M and α_E , which capture the association between income risk and imports and exports at the industry level.

Local Labor Market Level Analysis

Next, we conduct the analysis at the local labor market and regress the permanent component of income risk estimated for each district, cohort and panel on exposure to imports and exports per worker at the district level. Our specification is analogous with (6), where we regress the (logarithm of) permanent component of income risk estimated for each district, cohort and panel, $\sigma^2_{\varepsilon rpc}$, on level of imports and exports per worker at the district level:

$$\sigma^2_{\varepsilon rcp} = \gamma_0 + \gamma_M \cdot MPW_{rp} + \gamma_E \cdot EPW_{rp} + \gamma_r + \gamma_c + \gamma_p + \delta_r t + \vartheta_{rcp} \qquad (8)$$

In (8), district fixed effects, γ_r, are included to control for any time invariant district-specific factors that may affect the level of riskiness of earnings in the district. As before, we include on the right-hand side, panel and cohort fixed effects, γ_c, and γ_p, as well as district-specific time trends, $\delta_r t$. Finally, the district level trade exposure variables, MPW_{rp} and EPW_{rp}, measuring exposure to imports and exports at the district level are calculated as:

$$MPW_{rp} = \sum_j \frac{L_{rjp}}{L_{rp}} \times MPW_{j\square}$$

$$EPW_{rp} = \sum_j \frac{L_{rjp}}{L_{rp}} \times EPW_{jp} \qquad (9)$$

[5] Since our trade exposure measure is constructed over a panel, we consider several alternatives: annualized averaging across each panel, the observation at the beginning, mid-point, or one year prior to the beginning of the panel. In our regression analysis, we demonstrate that our core results are largely robust to the alternative constructions.

Here the magnitude of the trade shocks varies across local labor markets due to differences in initial industry composition. Specifically, $\frac{L_{rjp}}{L_{rp}}$ represents the share of industry *j* in region *r*'s total employment. As implied by (9), a region's exposure to imports, MPW_{rp} , is measured as the weighted sum of imports-per-worker, MPW_{jp} , across industries, with the employment ratios, $\frac{L_{rjp}}{L_{rp}}$ as the weights. Regional exposure to exports, EPW_{rp} , is similarly measured.

Table 5a reports average imports from the East and average exports to the East, by panel. Table 5b provides the corresponding values at the district level. Two observations may be made here. First, exports to Eastern Europe and, in most cases, imports from Eastern Europe, are higher than that of China. This is to say that German trade with Eastern Europe appears to quantitatively dominate, for most part, German trade with China. Second, trade with China and Eastern Europe has increased over time with the growth accelerating especially in the later years.

Endogeneity of Trade Shocks

An obvious concern in identifying the causal relationship between exposure to trade and income risk is that demand or productivity shocks at the industry or district level in Germany might be correlated with imports and exports.

To address this concern, we use trade (imports and exports) between the East and other high-income countries as instruments for trade exposure of Germany as in Dauth et. al. (2014) which itself is based on the construction of Autor et al. (2013). The "rise" of China and Eastern Europe, driven by an increase in their competitiveness, will have resulted in an increase in exports from the East to the rest of the world, as well as to Germany. The identification relies on the assumption that exports from the East to the rest of the world are correlated with exports to Germany, but largely uncorrelated with domestic German economic factors. Similarly, the imports of the East from the rest of the world are correlated with imports from Germany, without being correlated directly with factors specific to Germany and can potentially serve as instruments for German imports. In order to satisfy the exclusion restriction, in constructing the "other" high income countries group, we exclude all members of the European Monetary Union and a direct neighbor, Switzerland, as well as the United

States. The "other" countries included in the instrument group are Australia, Canada, Japan, Norway, New Zealand, Sweden, Singapore, and the United Kingdom. The instruments, at the industry level, are then calculated as follows:

$$IVMPW_{jp} = \frac{Import_{j,p-1}^{Other \leftarrow East}}{L_{j,p-1}}$$

$$IVEPW_{jp} = \frac{Export_{j,p-1}^{Other \rightarrow East}}{L_{j,p-1}}$$

The instruments at the district level are then calculated by simply weighting by lagged industry share in total district employment:

$$IVMPW_{rp} = \sum_{j} \frac{L_{rj,p-1}}{L_{r,p-1}} \times IVMPW_{jp}$$

$$IVEPW_{rp} = \sum_{j} \frac{L_{rj,p-1}}{L_{r,p-1}} \times IVEPW_{jp}$$

In addition, we also construct alternative IV measures by fixing the employment counts at the beginning of the sample period (1982) instead of lagging them by one panel.

Estimation Results

In Table 7 we report industry level results estimated for the full sample of workers from specification (8) identifying off exogenous variation in exports and imports. First three columns report the results with risk estimated by filtering out transitory shocks of duration less than a year (K=1 year) and the next three columns are estimated by filtering out transitory shocks of duration up to two years (K=2 years). First column includes panel fixed effects and industry fixed effects, the second column controls for shares of various education categories at the industry level in order to account for variation in risk across different education categories and the third column includes industry specific time trends. The sign and magnitude of coefficients are robust across these specifications: Higher levels of imports result in higher level of risk, whereas higher exports result in lower level of risk. Specifically, mean increase in imports per worker between 2000 and 2007, results in a 6% increase in income risk, while the mean increase in exports per worker, leads to a decline in income risk of about 8%. In Table A1 we replicate the analysis using the risk estimates based on an alternative Mincer regression with a much broader set of human capital measures included. The results are unchanged. Since the income variable in the IAB data is top-coded, we impute the income variable following Gartner (2005). Based on the risk estimates using the imputed data, the positive association between risk and imports remains statistically significant and economically sizable, while the negative association between risk and exports becomes largely insignificant.

In Table 8 we report additional robustness checks. Each column reports estimates from a specification with permanent component of income risk estimated by filtering out transitory shocks that last up to 1 year, as the dependent variable and includes panel and industry fixed effects, industry specific time trends and education level controls. Benchmark estimates reported in Table 7, are from the 2SLS specification exploiting exogenous variation in imports and exports per worker. Estimates in column (1) suggest our main conclusions are unchanged with an OLS specification, though estimated magnitudes are slightly smaller.

Next, we test whether our findings are sensitive to measurement of IPW and EPW. In our benchmark specification, in constructing the IPW and EPW measures, we use industry employment at the beginning of the previous panel and average exports and imports calculated over the 6-year panel. For estimates reported in column (2) we fix employment levels at 1982 and in column (3) measure exposure as of beginning of each panel rather than the average over the panel. Standard errors are clustered by industry instead of industry-year in benchmark in estimates reported in column (4) and risk for the last panel is estimated by omitting the financial crises years (2007 and 2008) in column (5). While our findings on imports are robust across these specifications, the link between exports and risk becomes slightly weaker with diminished statistical significance.

As we discussed earlier, income risk varies by year of entry to the labor market and over the lifetime of the worker. For the analysis reported in Table 9 we allow for permanent component of risk to vary by entry cohort as well as industry and panel. Each specification includes cohort fixed effects in addition to panel and industry fixed effects and industry specific time trends and education controls. The estimates as before suggest that exports increase risk and imports decrease risk. The results are robust to fixing the employment level at 1982, using beginning of panel imports and export measures instead of using averages and estimating risk by filtering out transitory shocks of up to 2 years.

The estimates reported in Table 10 at the district level are largely consistent with results at the industry level. Except for column (1), all the estimates are from specifications with risk that vary by district and panel as well as entry cohort as the dependent variable and that include cohort fixed effects as well as the set of controls from our benchmark specifications. In column (2) and (3) estimates are weighted by district population and are unweighted, respectively. In column (4) and (5) the instrument is constructed using fixed employment weights as of 1982 and using start of period trade instead of average trade. Column (6) reports estimates when risk is estimated only for the workers employed in the manufacturing sector in a district. Our main results are unchanged with imports increasing risk and exports decreasing risk; as expected the magnitude of estimates are larger for the manufacturing sector which is more directly impacted from trade.

Finally, in Table 11, we analyze separately the role of trade with Eastern Europe and China. In the first four columns IPW and EPW measure German trade with China, and the next four columns focus on trade with Eastern Europe. Industry level analysis is conducted by both pooling risk estimates and by allowing risk to vary by entry cohort. District level analysis is reported for full sample of workers and for only the manufacturing sample in a given district. The estimates suggest that while increase in imports from China and Eastern Europe increase risk, the evidence on the source of the negative association between exports and risk is mixed.

5. Conclusion

Using the rich worker-level employment biographies in Germany, this paper estimates income risk at both industry and district level over the period from 1982 to 2012. There is substantial variation in income risk across industries, districts, and different labor market entry cohorts. For a given entry cohort, we also find suggestive evidence that income risk varies non-monotonically with age. Interestingly, we note that risk estimates are largely consistent for additional worker-level controls being included in the underlying wage equation.

Going beyond risk estimation, we further examine the causal impact of trade exposure on income risk. Both industry- and district-level analysis reveal a strong positive association between imports and risk. The results are significant and sizable under a battery of robustness checks. Our trade regression also suggests a negative, albeit slightly less significant, impact of exports on risk. The less robust regression result perhaps captures the underlying theoretical ambiguity of how exports affect individual income risk.

Taken together, our results provide a comprehensive picture of how income risk in Germany evolves during the period of rapid globalization. The tight connection between risk and trade underscores the importance of understanding labor market consequences of trade beyond its level effects. Our analysis points to three open questions. First, despite the little change in risk estimates yielded by including measures of human capital specificity, it remains open how human capital specificity directly impacts the relationship between risk and exports and imports. Given the richness of the data, our risk estimates can be conducted by re-grouping individuals into those with high or low level of specific human capital, which can be proxied by industry, occupation, and, perhaps most interestingly, task-based tenure. Second, in light of Guvenen, et al. (2019), it would be interesting to investigate how the higher-order earnings risk varies across industries and districts in a systematic way in relation to trade. Third, as we have documented, the rise of Eastern Europe and China seems to have differential impact on income risk of German workers but it is not entirely clear whether the explanation based on the difference in structure of imports as in Dauth et al. (2014) could account for the difference in risk outcomes. We envisage all these questions would be fruitful avenues for future research.

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Table 1 Risk Estimates: Industry level

	Risk (K=1 year)		Risk (K=2 years)		N	
	Mean	Std. Dev.	Mean	Std. Dev.	Total	Industry
1983-88	0.0035	0.0016	0.0033	0.0017	455,842	5,009
1989-94	0.0029	0.0014	0.0027	0.0019	850,809	9,248
1995-2000	0.0022	0.0008	0.0021	0.0010	1,003,660	10,909
2001-06	0.0022	0.0009	0.0022	0.0011	1,127,662	12,257
2007-12	0.0016	0.0008	0.0014	0.0010	1,191,517	12,951

Note: (1) Reported mean and standard deviations are calculated across point estimates for 92 manufacturing industries (3-digit NACE Rev. 1.0), in each panel for the pooled sample; (2) 91 industries for the first panel.

Table 2 Risk Estimates: District level

	Risk (K=1 year)		Risk (K=2 years)		N	
	Mean	Std. Dev.	Mean	Std. Dev.	Total	Industry
1983-88	0.0039	0.0010	0.0036	0.0012	1,287,526	3,974
1989-94	0.0031	0.0006	0.0030	0.0008	2,183,010	6,738
1995-2000	0.0024	0.0005	0.0022	0.0006	2,816,418	8,693
2001-06	0.0027	0.0006	0.0027	0.0006	3,262,551	10,070
2007-12	0.0023	0.0005	0.0022	0.0006	3,613,290	11,152

Note: Reported mean and standard deviations are calculated across point estimates for 324 districts in former West Germany (excluding Berlin), in each panel.

Table 3 Risk Estimates by Cohort: Industry level (K=1 year)

	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
	6 years		12 years		18 years		24 years		30 years		36 years	
1983-88	0.0063	0.003	0.0023	0.001								
1989-94	0.0053	0.004	0.0027	0.001	0.0016	0.001						
1995-2000	0.0050	0.004	0.0026	0.001	0.0016	0.001	0.0013	0.001				
2001-06	0.0088	0.005	0.0024	0.002	0.0019	0.002	0.0016	0.001	0.0017	0.001		
2007-12	0.0048	0.003	0.0024	0.002	0.0015	0.002	0.0011	0.001	0.0011	0.001	0.0013	0.002

Note: (1) Reported mean and standard deviations are calculated across point estimates for 92 manufacturing industries (3-digit NACE rev. 1.0), in each panel and entry cohort; (2) The third row is the number of years from the entry into labor market to the end of a given panel.

Table 4 Risk Estimates by Cohort: District level (K=1 year)

	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
	6 years		12 years		18 years		24 years		30 years		36 years	
1983-88	0.0066	0.003	0.0021	0.001								
1989-94	0.0044	0.003	0.0026	0.001	0.0017	0.001						
1995-2000	0.0048	0.003	0.0025	0.001	0.0015	0.001	0.0013	0.001				
2001-06	0.0086	0.005	0.0023	0.002	0.0017	0.001	0.0013	0.001	0.0015	0.001		
2007-12	0.0042	0.003	0.0026	0.002	0.0014	0.002	0.0010	0.001	0.0010	0.002	0.0012	0.002

Note: (1) Reported mean and standard deviations are calculated across point estimates for 325 districts in former West Germany, in each panel and entry cohort; (2) The third row is the number of years from the entry into labor market to the end of a given panel.

Table 5a Trade Exposure: Industry Level (N = 92)

	China		Eastern Europe	
	Imports	Exports	Imports	Exports
1983-88	0.56	0.52	1.31	2.43*
1989-94	2.71	0.49	3.43	5.58
1995-2000	6.13	0.86	8.17	10.16
2001-06	13.56	2.17	13.68	17.55
2007-12	28.66	4.55	17.80	27.96

* The industry producing pesticides and other agro-chemical products (NACE = 242) stands out clearly as an outlier so it is omitted in our calculation of the average exports to Eastern Europe in the 1983-88 panel.

Table 5b Trade Exposure: District Level (N = 324)

	China		Eastern Europe	
	Imports	Exports	Imports	Exports
1983-88	0.13	0.17	0.43	0.76
1989-94	0.41	0.17	0.81	1.11
1995-2000	0.70	0.28	1.88	2.27
2001-06	1.56	0.87	3.07	4.02
2007-12	2.77	1.89	3.92	5.76

Table 6 First Stage Regressions: Industry-Level

	Average MPW			Average EPW		
Average MPW- Other	0.386***	0.397***	0.370***	0.035*	0.039*	0.054**
	(0.035)	(0.037)	(0.041)	(0.020)	(0.021)	(0.014)
Average EPW- Other	0.120**	0.104*	0.103	0.396***	0.388***	0.346***
	(0.035)	(0.057)	(0.067)	(0.051)	(0.049)	(0.030)
Panel Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects (nace3)	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Spec (nace2) Time Trend	No	No	Yes	No	No	Yes
Education Controls	No	Yes	Yes	No	Yes	Yes
N	457	457	457	457	457	457
R2	0.892	0.898	0.920	0.840	0.842	0.898

Note: Robust standard errors in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 7 International Trade and Income Risk: Industry Level

	K= 1 year			K= 2 years		
Average MPW	0.003***	0.002***	0.003***	0.004***	0.003***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Average EPW	-0.006***	-0.005***	-0.003**	-0.008***	-0.007***	-0.005*
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Panel Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects (nace3)	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Spec (nace2) Time Trend	No	No	Yes	No	No	Yes
Education Controls	No	Yes	Yes	No	Yes	Yes
N	457	457	457	453	453	453
R2	0.869	0.889	0.909	0.772	0.796	0.824

Note: (1) Regression is weighted by the employment count for each industry-panel; (2) Standard errors clustered at the industry-panel level are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 8 International Trade and Income Risk – Robustness

K=1 Year	OLS	IV weights fixed at 1982	Start of Period Trade Exposure	Cluster by nace	Last panel omitted
MPW	0.002**	0.003**	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
EPW	-0.003***	-0.001	-0.004**	-0.003*	0.001
	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)
Panel Fixed Effects	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects (nace3)	Yes	Yes	Yes	Yes	Yes
Ind-Spec (nace2) Time Trend	Yes	Yes	Yes	Yes	Yes
Education Controls	Yes	Yes	Yes	Yes	Yes
N	457	457	457	457	366
R2	0.909	0.907	0.908	0.909	0.881

Note: (1) Regression is weighted by the employment count for each industry-panel; (2) Standard errors clustered at the industry-panel level are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 9 International Trade and Income Risk – by-cohort Analysis

		IV weights fixed at 1982	Start of Period Trade	K= 2 years
MPW	0.005**	0.008***	0.005***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)
EPW	-0.007***	-0.005	-0.007***	-0.011***
	(0.003)	(0.004)	(0.003)	(0.003)
Panel Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects (nace3)	Yes	Yes	Yes	Yes
Ind-Spec (nace2) Time Trend	Yes	Yes	Yes	Yes
Education Controls	Yes	Yes	Yes	Yes
Cohort Fixed Effects	Yes	Yes	Yes	Yes
N	4136	4136	4136	3931
R2	0.694	0.691	0.693	0.584

Note: (1) Regression is weighted by the employment count for each industry-panel-cohort; (2) Standard errors clustered at the industry-panel level are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 10 International Trade and Income Risk: District Level

	Pooled	Weighted	Unweighted	IV weights fixed at 1982	K=2 years	Start of Period Trade	Manufacturing Sector
MPW	0.050***	0.046***	0.053***	0.037	0.053**	0.043**	0.036*
	(0.015)	(0.017)	(0.021)	(0.033)	(0.023)	(0.020)	(0.035)
EPW	-0.022***	-0.028***	-0.033**	-0.030***	-0.033**	-0.033***	-0.009
	(0.008)	(0.008)	(0.012)	(0.009)	(0.013)	(0.008)	(0.013)
Panel Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Specific Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Educ./ Man. Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort Fixed Effects	No	Yes	Yes	Yes	Yes	Yes	Yes
N	1620	15,893	15,893	15,893	15,196	15,893	14,651
R2	0.861	0.619	0.486	0.619	0.482	0.619	0.415

Note: (1) Regression is weighted by the employment count for each district-panel(-cohort), unless otherwise stated; (2) Standard errors clustered at the district-panel level are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 11 International Trade and Income Risk - Eastern Europe vs China

	China				Eastern Europe			
	Industry		County		Industry		County	
	Pooled	By Cohort	All	Manuf.	Pooled	By Cohort	All	Manuf.
MPW	0.002*	0.005**	0.048**	0.044*	0.007*	0.003	0.100***	0.049
	(0.001)	(0.002)	(0.022)	(0.026)	(0.004)	(0.004)	(0.034)	(0.047)
EPW	-0.006	-0.017**	-0.050**	-0.019	-0.005	-0.003	-0.065***	-0.001
	(0.005)	(0.007)	(0.020)	(0.026)	(0.004)	(0.006)	(0.032)	(0.045)
Panel Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Varying Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	No	No	Yes	Yes	No	No
Industry-Specific Time Trend	Yes	Yes	No	No	Yes	Yes	Yes	Yes
County Fixed Effects	No	No	Yes	Yes	No	No	Yes	Yes
Region-Specific Time Trend	No	No	Yes	Yes	No	No	Yes	Yes
Cohort Fixed Effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
N	457	4136	15893	14651	457	4136	15893	14651
R2	0.908	0.693	0.619	0.416	0.908	0.694	0.618	0.415

Note: (1) Regression is weighted by the employment count for each industry/district-panel(-cohort); (2) Standard errors clustered at the industry/district-panel level are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table A1 International Trade and Income Risk: Industry Level

	K= 1 year			K= 2 years		
Average MPW	0.003***	0.002***	0.002***	0.004***	0.003***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Average EPW	-0.006***	-0.005***	-0.003**	-0.008***	-0.007***	-0.005**
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Panel Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects (nace3)	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Spec (nace2) Time Trend	No	No	Yes	No	No	Yes
Education Controls	No	Yes	Yes	No	Yes	Yes
N	457	457	457	457	457	457
R2	0.873	0.894	0.912	0.750	0.775	0.794

Note: (1) Estimation of income risk is based on a Mincer regression with a wide array of beginning-of-panel controls included (tenure measures, task-based measures of human capital specificity) (2) Regression is weighted by the employment count for each industry-panel; (3) Standard errors clustered at the industry-panel level are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table A2 International Trade and Income Risk: Industry Level

	K= 1 year			K= 2 years		
Average MPW	0.002***	0.001**	0.002***	0.003***	0.002**	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Average EPW	-0.001	-0.002	-0.001	-0.002	-0.003	-0.003
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)
Panel Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects (nace3)	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Spec (nace2) Time Trend	No	No	Yes	No	No	Yes
Education Controls	No	Yes	Yes	No	Yes	Yes
N	457	457	457	457	457	457
R2	0.742	0.796	0.835	0.576	0.640	0.689

Note: (1) Estimation of income risk is based on the imputed income data; (2) Regression is weighted by the employment count for each industry-panel; (3) Standard errors clustered at the industry-panel level are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.