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# international trade and the occupational mix in manufacturing: evidence from german micro data

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# International Trade and the Occupational Mix in Manufacturing: Evidence from German Micro Data

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## Abstract

We use the Establishment History Panel from 1975 to 2010 provided by the German Federal Employment Office to examine the impact of international trade on the occupational structure of the German manufacturing sector. To capture trade, we match the Establishment History Panel with UN Comtrade trade data. To do so, we develop a new matching approach that takes the input and output structure of the German manufacturing sector into account. We identify three different trade channels: import intensity, import competition, and export intensity. Using a fixed-effects Poisson regression model, we find diverse occupational effects from trade at the industry-level, while establishment-level estimations show only few significant effects.

**Keywords:** International Trade, Occupational Mix, Firm Organization

**JEL codes:** J21, F16, F61, L23

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# 1 Introduction

The impact of international trade on employment has been a widely discussed topic in the economic literature, political debates, and the popular press. Surprisingly enough, rather little empirical research has been conducted to shed light on how trade openness impacts the employment in different occupations, despite the fact that the employment structure in industrialized nations have undergone a substantial change during the past decades. In Germany, for instance, the share of employment in service occupations within manufacturing experienced a steep increase of about 29% since 1975. During the same time period the inflation-adjusted trade volume increased approximately by a factor of five. While much has been written on structural change as an inter-sectoral process<sup>1</sup>, we, by contrast, focus on intra-sectoral employment changes within the German manufacturing sector.

The purpose of the current paper therefore is to examine the role of international trade as one potential driving force behind the change of the occupational mix within establishments in the manufacturing sector. We identify three potential channels through which establishments are affected by trade and thus adapt their employment: first, the import of inputs and intermediate goods used in the production process ("import intensity"), second, the import of goods that compete with final goods of domestic establishments ("import competition"), third the export of goods that are produced by domestic establishments ("export intensity").

To our knowledge, this paper is among few papers that examine the effect of international trade on the employment of very disaggregated occupational groups and the only one that simultaneously considers three trade channels. In contrast to other studies that only distinguish between highly aggregated employment groups, e.g. high-skilled and low-skilled employees or production and non-production workers, we are able to investigate much more precisely, which employees benefit or suffer from the increasing exposure to international trade. This might be of great relevance for policy implications - e.g. in the field of labor market policies or educational policies - because our results allow for more targeted actions compared to studies that analyze more aggregated employment groups. In our empirical analysis, we focus on Germany, which is among the most active countries in international trade. We use the "Establishment History Panel" (in German: Betriebs-Historik-Panel (BHP)), a very detailed micro data set provided by the German Federal Employment Office covering the years from 1975 to 2010, a time span that exceeds all other studies in

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<sup>1</sup>See for example Kuznets (1966), Jorgenson & Timmer (2011) and Alvares-Cuadrado & Long (2011).

the field. The data set allows us to have unique insight into the occupational mix of all German establishments in the manufacturing sector over a 36-year period and to observe changes in the employment composition in detail. Beyond the estimation at the industry-level, we are able to estimate the impact of international trade at the establishment-level and control for establishment fixed-effects, which improves the estimation quality in comparison to various other studies that only use industry-level data.<sup>2</sup>

We match the BHP at the industry-level with trade data provided by the UN Comtrade database at the commodity-level, as the core data set does not contain information on activities in international trade. We then apply a fixed-effects Poisson model for the estimations at both the industry- and the establishment-level. The former level of aggregation allows us to estimate our empirical model with data that are all on the same level of aggregation, whereas the latter specification is able to control for the substantial establishment heterogeneity.

The results at the industry-level indicate that import intensity and import competition decrease employment and export intensity increases employment. It is the employment in unskilled service occupations that mainly face job losses from an increase in imports of intermediates. Employees in lower skilled occupations, especially in services and administration, suffer most from an increase in competition with foreign firms, whereas the employment of these occupations rises the most from an increase in exports. Among the production occupations the employment of technicians reacts the most to changes in trade. Our results at the establishment-level only show few significant trade effects on the occupational mix.

This paper is related to four strands of literature. First, there is a large body of literature that explores employment effects of changes in import intensity. This channel is commonly named "offshoring" or "trade in tasks". According to Grossman & Rossi-Hansberg (2008), firms are able to unbundle the production process into a continuum of tasks. Decreasing costs of offshoring are associated with an increasing number of tasks that can be outsourced to low-wage countries. Offshorable tasks are generally considered to be routine tasks, whereas non-routine tasks remain in the domestic firm (Baldwin & Robert-Nicoud (2007)). As production tasks are more likely to be the ones that are of a routine nature and do not require physical proximity, outsourcing is supposed to decrease the employment of (low-skilled) production occupations. While these papers can give theoretical explanations for changes in the occupational mix, few empirical studies distinguish between different occupational groups (e.g. Hogrefe (2013)). Most papers only dis-

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<sup>2</sup>See for example Feenstra & Hanson (1996).

tistinguish between aggregated employment groups, for example between routine and non-routine tasks (e.g. Becker, Ekholm & Muendler (2013)) or between different skill levels (e.g. Hijzen et al. (2005)). Using disaggregated plant data for Germany, Becker, Ekholm & Muendler (2013) estimate that offshoring leads to a significant shift toward non-routine tasks and high-skilled workers, in particular if offshoring to low-income countries is considered. Hijzen et al. (2005) and Hogrefe (2013) confirm these findings. However, these studies focus exclusively on the employment effects of offshoring. In contrast, we analyze the employment effects of three trade channels on very disaggregated occupational groups.

Second, there is a growing literature on the employment effect of import competition. Increasing import competition is supposed to reduce employment, especially in production occupations, since imported final goods substitute the goods of domestic suppliers. In contrast to most papers in the field<sup>3</sup>, we analyze the employment effects of rising import competition on a much more disaggregated level. An exception is the paper by Biscourp & Kramarz (2007), who regard the effect of all three trade channels on the employment at the firm-level. Their focus, however, is the skill structure rather than the occupational mix of firms. The authors confirm job losses due to increasing imports of final goods. Furthermore, they observe that especially large firms mostly reduce the employment in (low-skilled) production occupations.

Third, there is a comparatively small literature on the role of exporting as a determinant of the occupational mix. Preexisting literature in this field<sup>4</sup>, however, mainly focuses on total employment effects or, at most, distinguishes between a limited number of groups of employees such as production and non-production or high-skilled and low-skilled.

Fourth, this paper contributes to the growing literature that discusses the link between international trade and firm organization. However, the emphasis of this literature is mainly on firm organization from a management perspective rather than

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<sup>3</sup>Among the papers are Autor, Dorn & Hanson (2013), who analyze the regional employment effects of import competition from China in the United States. They conclude that regions competing with Chinese imports to a high degree have suffered from rising unemployment. This result is confirmed by Tomiura (2003) for Japan.

<sup>4</sup>Among the papers are Bernard & Jensen (1997), Mauro, Thesmar & Koenig (2002), and Biscourp & Kramarz (2007). Biscourp & Kramarz (2007) find that for French firms exports have a negative impact on the unskilled share in manufacturing employment, but a positive impact on the share of production jobs because increasing exports require a rise in the production of domestic firms. Davidson et al. (2013) distinguish between different occupational groups. They find that exporters, especially multinational exporters, have an occupational distribution toward the more skilled.

on the organization formed by different occupational groups.<sup>5</sup>

To match the commodity classification of the trade data and the industry classification of the BHP, we use the "Statistic concerning Materials and Commodities received by the Industries" (in German: Material- und Wareneingangserhebung im Verarbeitenden Gewerbe, hereafter called "Input Statistic") and the "Survey of Production" (in German: Produktionserhebung im Bereich Verarbeitendes Gewerbe), both provided by the German Federal Statistical Office. The first allows us to allocate the imported intermediate goods according to the input structure of the German manufacturing sector to obtain a measure of "import intensity". The latter allows us, on the one hand, to construct a measure of "import competition" by allocating imports according to the output structure of the German manufacturing sector. On the other hand, we construct a measure for "export intensity" by allocating export flows according to the output structure.

The rest of the paper is organized as follows. In the next two sections, we present the data and some stylized facts about changes in the employment in Germany. Section 4 discusses the matching approach, the estimation strategy and the empirical results. The final section concludes and summarizes.

## 2 Data

We base our calculations on the "Establishment History Panel" (in German: Betriebs-Historik-Panel (BHP)) provided by the Research Data Center of the German Federal Employment Office.<sup>6</sup> The "Establishment History Panel" is a detailed micro-level data set that covers all establishments in Germany from 1975 to 2010 (for the 1975-1990 period, it includes only establishments in West Germany) with at least one employee subject to social insurance contributions before June 30th of the respective year.<sup>7</sup> For our calculations, we are able to use a 50% random sample of the entire data set. The BHP builds on the "Employee History" (in German: Beschäftigten-Historik (BeH)) of the IAB. It cumulates the individual data

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<sup>5</sup>For instance, Caliendo & Rossi-Hansberg (2012) develop a model that shows an increase in management layers as a result of exporting. Marin et al. (2014) implement trade in tasks into a theory of the firm organization à la Marin & Verdier (2012). They show both theoretically and empirically that offshoring leads to a more decentralized management.

<sup>6</sup>For our research, we have access to the data via on-site use at the Research Data Center of the German Federal Employment Agency at the Institute for Employment Research (in German: Institut für Arbeitsmarkt- und Berufsforschung (IAB)), at various external FDZ locations and via remote data access.

<sup>7</sup>Since 1999, there are also all establishments with at least one part-time employee included in the panel.

of the BeH to the establishment-level and assigns individual establishment numbers ("artificial establishment numbers"). Thus, it is possible to identify the establishments in subsequent years and create a panel data set for the entire 1975-2010 period. Because the "Establishment History Panel" is based on the "Employee History", it provides very detailed information on the general employment structure of each establishment, e.g. the total number of full-time employees, the composition of employment regarding employees' educational and vocational qualifications and the occupational status according to the Blossfeld occupational groups (Blossfeld (1987) and Appendix 1). In addition, the data set also contains information on general establishment characteristics, such as the 3-digit classification of economic activities and a proxy for activities in R&D.<sup>8</sup> For our analysis, we concentrate on the manufacturing sector. Since the BHP only provides information on establishments rather than on firms, changes in the occupational mix of firms are not observable because we do not know if single establishments are part of a parent firm or not.

We match the BHP with a data set that contains constructed time-consistent industry codes, because the classification of economic activities changes several times within the 1975-2010 period.<sup>9</sup> Hence, we are able to consistently control for industry-specific effects at the 3-digit level (according to the classification of economic activities 93) in our regressions.

We additionally match the BHP with trade data, which we obtain from the UN Comtrade database. For the matching process, we use the Input Statistic and the Survey of Production provided by the German Federal Statistical office that gives us detailed information on the input and output structure of the German manufacturing sector. A more detailed description of the matching process used will be provided in section 4.1. We only consider establishments with at least 20 employees.<sup>10</sup> Overall our sample consists of 379.805 observations, which includes 69.069 different establishments. For every establishment, the data set contains information on the number of employees in each Blossfeld occupational group (Blossfeld (1987)). The classification includes three main categories: production, service, and administration - each of which contains three to four sub-categories ordered by their skill level.

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<sup>8</sup>For further information concerning the BHP, see Gruhl et al. (2012) (German version) or Hethey-Maier & Seth (2010) (English version).

<sup>9</sup>For a more detailed description concerning the construction of the data set, see Eberle, Jacobebinghaus, Ludsteck & Witter (2011).

<sup>10</sup>We have to restrict the establishment size as the Survey of Production, our basis for the derivation of German export flows, only captures establishments with at least 20 employees.



### 3 Stylized Facts

Using the occupational information of the BHP, we can show that the increasing share of service employment, measured at the establishment-level, is much higher than indicated by standard measurements at the industry-level (Henze (2014)).

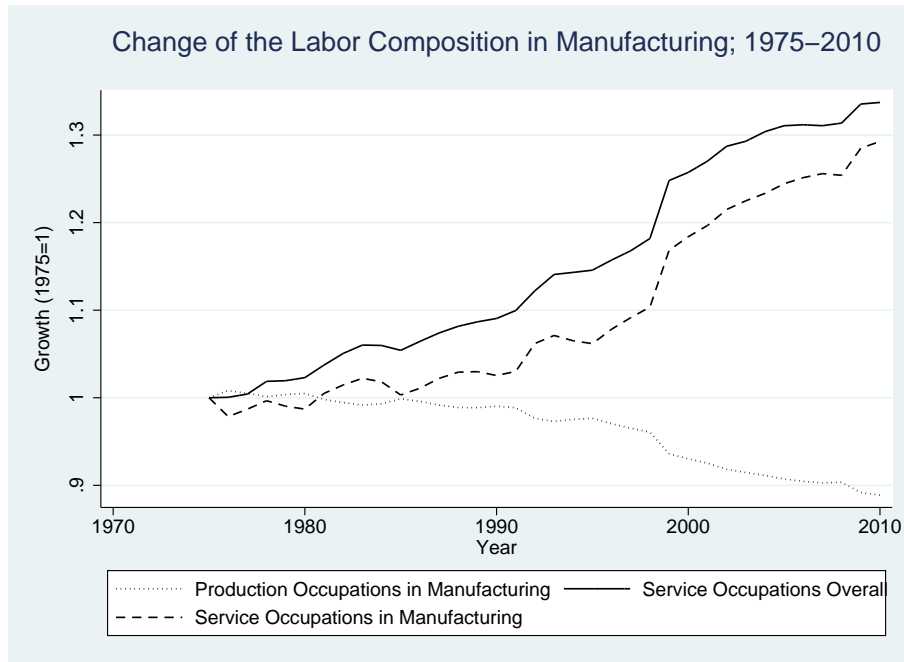


Figure 1:  
Change in the occupational Mix in Manufacturing  
**Source:** "Establishment History Panel", authors' computation.

Figure 1 shows the change in the occupational mix in the German manufacturing sector between 1975 and 2010. The dashed line shows the employment growth of full-time employees in service occupations in manufacturing establishments.<sup>11</sup> In the 36-year period, the employment in service occupations increased by 29%. For the German economy as a whole, it increased by 34% during the same period (solid line). In contrast, the employment in production occupations in the manufacturing sector decreased by 12%. These findings highlight the substantial change of the occupational mix in manufacturing, but give little evidence of driving forces behind the transition.

To shed light on this issue, Table 1 depicts the employment growth of each occupational group. Column 2 shows the absolute employment in 1975 and column 3 the overall change until 2010. It becomes obvious that the increase in the employment

<sup>11</sup>Here, administrative occupations are considered to be related to services, too. Therefore, service occupations also include administrative occupations.

Table 1: Employment Growth of occupational Groups in Manufacturing, 1975-2010

Occupational Group	Abs. Employment (1975)	Growth overall
<b>Production</b>		
Unskilled manual occupations	1.506.494	-33,66%
Skilled manual occupations	934.780	-14,60%
Technicians	269.634	+4,74%
Engineers	82.243	+105,81%
<b>Services</b>		
Unskilled services	306.833	-18,91%
Skilled services	22.146	-19,32%
Semiprofessions	10.684	+66,26%
Professions	7765	+51,33%
<b>Administration</b>		
Unskilled commercial and administrative occupations	196.622	+6,31%
Skilled commercial and administrative occupations	412.995	+20,01%
Managers	70.592	+17,05%
<b>Source:</b> "Establishment History Panel", authors' computation.		

share in service occupations was largely driven by a decrease of the employment in production occupations. Within the 36 years of observation, more than half a million production jobs (about 20%) were lost - the biggest part coming from a decrease in the employment in unskilled manual occupations. Overall, the number of non-production workers in manufacturing slightly increased. This was mostly driven by an increase in the employment in administrative occupations, whereas employment in service occupations overall showed a slight decrease. Since the employment in production occupations decreased to such a large extent, the share of employment in service and administrative occupations increased. Moreover, it is the employment in the most skilled occupations that grew, whereas employment in unskilled occupations declined. This observation holds for both production and services. While the employment in the two least skilled occupations in production and services decreased by 15% to 34%, the two most skilled occupational groups experienced employment increases of 5% to 106%. In administration, the employment in all categories showed an increase, while the employment in less skilled occupations experienced lowest employment growth. Thus, the occupational structure in manufacturing also changed toward the more skilled.

## 4 Empirical Evidence

### 4.1 Matching of Commodity Trade Data

As there is no long-term micro data set for Germany available that includes information on both employment structure and trade flows, we create our data set by merging trade data from the UN Comtrade database with the BHP. This requires converting commodity trade data into industry trade data. However, instead of using correspondence tables to assign each trade commodity to the most similar industries, we allocate the trade flows according to the actual input and output structure of the German manufacturing sector. For that, we use two data sets provided by the German Federal Statistical Office: the Input Statistic (in German: Material- und Wareneingangserhebung im Verarbeitenden Gewerbe) to allocate the imports and generate import intensity, and the Survey of Production (in German: Produktionserhebung im Bereich Verarbeitendes Gewerbe) to allocate German exports and imports to generate export intensity and import competition.

The Input Statistic is published every four years starting from 1978. It provides information on all incoming materials and commodities in Germany at the 2-digit or 3-digit level for all 3-digit manufacturing industries. With this information at hand, we derive the import intensity for the German manufacturing sector in the following way:

$$ImpInt_{it} = \sum_{c=1}^N \frac{x_{cit}}{x_{ct}} * \gamma_{ct} * Import_{ct}, \quad (1)$$

where import intensity  $ImpInt_{it}$  is the calculated import flow into a specific industry  $i$  in year  $t$ .  $x_{cit}$  stands for the input of commodity  $c$  in this industry  $i$  in year  $t$ ,  $x_{ct}$  is the total input of commodity  $c$  in year  $t$  over all industries, and  $Import_{ct}$  is the import flow<sup>12</sup> for each commodity in a given year. As the trade data do not distinguish between the usage of imports, e.g. manufacturing inputs or private and government consumption, we weigh the commodity-specific import with its share of manufacturing input,  $\gamma_{ct}$ ,<sup>13</sup> before we allocate the commodity imports to the industries. Accordingly, we avoid overestimating the importance of commodities mostly used by recipients other than manufacturing (e.g. consumer intensive goods

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<sup>12</sup>All trade flows obtained from the UN Comtrade database are inflation-adjusted.

<sup>13</sup>The commodity-specific import shares of manufacturing are obtained from the input-output tables provided by the German Federal Statistical Office. Since the input-output tables for Germany are only available for the 1995-2010 period, we have to assume that the industry-specific input shares from 1975-1995 are constant. A comparison of later years shows that the input shares are rather stable. Therefore, our assumption seems to be appropriate.

such as textiles).<sup>14</sup> By weighing the imports, we additionally make sure that to a great extent only intermediates rather than final goods are accounted for.<sup>15</sup>

To obtain the export intensity, we allocate the commodity exports using the Survey of Production. The Survey of Production reports all commodities at the 8-digit level that are produced in each 4-digit industry for the 1995-2010 period.<sup>16</sup> Analogously to our approach for import intensity, we derive export intensity by:

$$ExpInt_{it} = \sum_{c=1}^N \frac{z_{cit}}{z_{ct}} * Export_{ct}, \quad (2)$$

where export intensity  $ExpInt_{it}$  is the calculated export of industry  $i$  in year  $t$ ,  $z_{cit}$  is the output of commodity  $c$  in this industry  $i$  and year  $t$ , and  $z_{ct}$  stands for the total output of commodity  $c$  in year  $t$ .  $Export_{ct}$  is the export flow for each commodity in a given year. Similar to the import flows, we are able to allocate the export commodities to industries on the basis of the actual production structure the Survey of Production provides.<sup>17</sup>

To generate import competition, we again use the Survey of Production. This time, however, we allocate the imports according to the output structure such that the import competition is derived by:

$$ImpComp_{it} = \sum_{c=1}^N \frac{z_{cit}}{z_{ct}} * Import_{ct}. \quad (3)$$

Here, we assume that establishments face import competition, when products are being imported that match the domestic establishments' production at the 9-digit commodity-level.

In the following section, we introduce these measures of trade exposure to estimate the effects of an increasing openness to trade on the occupational mix of

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<sup>14</sup>We believe that mostly recipients other than manufacturing use final good imports, whereas imports flowing into the manufacturing sector will mostly be intermediate goods. Accordingly, final goods are filtered out if we only use the share of imports flowing into the manufacturing sector. The only cases in which final goods are allocated to the manufacturing sector are if either the product is used as capital input (e.g. machinery) or if the establishment is partly reselling final products. Establishments that mostly or purely resell are part of the service sector.

<sup>15</sup>For example, the Input Statistic in 2000 shows that goods of "Leather and Leather Manufactures" are used in 17 industries as an input factor. Using a single correspondence table instead, we would allocate leather imports to only four industries.

<sup>16</sup>We have to assume a constant output structure from 1975 to 1994 that is equal to the structure of 1995, because the Survey of Production only starts in 1995.

<sup>17</sup>As before, the example of "Leather and Leather Manufactures" shows that we allocate exports to 24 industries, compared to only four industries in case of a single correspondence table.

German manufacturing establishments.

## 4.2 Empirical Strategy

In order to explain the effects of international trade on the occupational mix, we use a fixed-effects Poisson model. We investigate how international trade affects the absolute number of employees of different occupational groups, such that our dependent variable only consists of integer values (count data) that follow a Poisson distribution. We estimate the employment effects of international trade both at the establishment-level and at the industry-level. To apply the fixed-effects Poisson model, we use the Generalized Method of Moments (GMM). One concern of our empirical analysis is to control for the substantial individual heterogeneity by including fixed-effects for establishments or industries (depending on the specification) in our estimations, i.e. introduce a dummy variable for each establishment or industry. We thus follow Blundell, Griffith & Windmeijer (2002) to apply a GMM estimation approach of the Poisson model in a panel data context that uses a moment condition rather than the full likelihood function. Thus, we are able to account for the substantial individual heterogeneity without using dummy variables for each establishment or industry.

A "standard Poisson regression model" that is commonly used for count data can be written as:

$$E(y_{jt}|x_{jt}) = \exp(x'_{jt}\beta), \quad (4)$$

where  $y_{jt}$  is the dependent discrete count variable for establishment  $j$  at time  $t$ ,  $x_{jt}$  the vector of explanatory variables and  $\beta$  the vector of estimated coefficients.<sup>18</sup> This Poisson regression model can be rewritten as the following moment condition (under the assumption that all independent variables are strictly exogenous):

$$E \left[ x_{jt} \left\{ y_{jt} - \exp(x'_{jt}\beta) \right\} \right] = 0. \quad (5)$$

An important issue in our estimations is the unobserved heterogeneity of industries and establishments. We use the moment condition according to equation (5) for panel data and additionally include a term for individual heterogeneity (a fixed-effect),  $\eta_j$ . For count data models, this term is generally added multiplicatively.

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<sup>18</sup>For regressions at the industry-level, the derivation of the moment condition is very similar to the one at the establishment-level. In case of industry-level estimations, we only substitute the index  $j$  for each establishment by the index  $i$  for each industry. Hence, we are able to account for the individual heterogeneity of each industry.

Then, we obtain

$$E(y_{jt}|x_{jt}, \eta_j) = \exp(x'_{jt}\beta + \eta_j) = \mu_{jt}\nu_j, \quad (6)$$

where  $\mu_{jt} = \exp(x'_{jt}\beta)$  and  $\nu_j = \exp(\eta_j)$  is the permanent scaling factor for the individual mean. Hence, our regression model looks as follows:

$$y_{jt} = \mu_{jt}\nu_j + \epsilon_{jt}, \quad (7)$$

where  $\epsilon_{jt}$  is the error term. If all  $x_{jt}$  are strictly exogenous<sup>19</sup>, we can finally rewrite our sample moment condition as:

$$\sum_{j=1}^N \sum_{t=1}^T x_{jt} \left( y_{jt} - \mu_{jt} \frac{\bar{y}_j}{\bar{\mu}_j} \right) = 0. \quad (8)$$

Here,  $\bar{y}_j$  and  $\bar{\mu}_j$  are the means of  $y_j$  and  $\mu_j$  for panel  $j$ , i.e. the respective establishment. This moment condition, where the fixed-effects are substituted by the ratio of within group means is now equivalent to a "standard Poisson regression model" with establishment fixed-effects. The "mean scaling" model can now be written as:

$$y_{jt} = \mu_{jt} \frac{\bar{y}_j}{\bar{\mu}_j} + \epsilon_{jt}^*. \quad (9)$$

Blundell, Griffith & Windmeijer (2002) describe this estimator as the "within group mean scaling estimator".

Finally, we are able to estimate our extensive micro data set by using a GMM Poisson model with the moment condition according to equation (8), which yields the same results as the "standard Poisson regression model" with dummy variables for each establishment or each industry, respectively. In addition, the GMM estimator has very strong robustness properties concerning the possible presence of overdispersion<sup>21</sup> and serial correlation (Wooldridge (2002)).

To estimate the effects of international trade on the occupational mix, we develop two specifications of our empirical model. As mentioned above, the BHP provides detailed information at the establishment-level, but our trade data are only available at the 3-digit industry-level. Hence, we first estimate our empirical model at the

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<sup>19</sup>If the explanatory variables are strictly exogenous, the conditional mean of  $y_{jt}$  satisfies  $E(y_{jt}|\nu_j, x_{jt}) = E(y_{jt}|\nu_j, x_{j1}, \dots, x_{jT})$ .

<sup>20</sup> $\epsilon_{jt}^* = \epsilon_{jt} - (\epsilon_{jt}/\bar{\epsilon}_j) \bar{\epsilon}_j$ .

<sup>21</sup>One of the crucial assumptions of the Poisson distribution is that the variance of the dependent variable  $Y$  equals its mean:  $Var(Y) = E(Y)$ . However, empirically, there is often the presence of overdispersion, i.e. the variance is larger than the mean.

industry-level. To do so, we aggregate the information of the BHP to the 3-digit industry-level. This specification has the advantage that all variables are measured at the same level of aggregation. Moreover, it allows us to compare our results with the related literature that mainly focuses on industry-level data. On the other hand, this specification does not allow us to control for a wide range of establishment characteristics as well as for establishment fixed-effects. Therefore, we apply a second specification that estimates our empirical model as disaggregated as possible. Here, we estimate all variables except the trade flows and some control variables at the establishment-level which allows us to account for the unobserved establishment heterogeneity, i.e. establishment fixed-effects. However, we now measure the variables for employment and international trade at different levels of aggregation. Thus, it might be difficult to determine employment effects within establishments due to changing trade flows of the corresponding industry. In addition, there is the chance that decisions about occupational structures are made at the firm-level rather than at the establishment-level. Accordingly, changes in the occupational mix of firms due to international trade might not be observable, since we only see single establishments without knowing whether they are part of a parent firm or not.

First, we estimate the employment effects of international trade at the industry-level. We set the respective industry identifier (3-digit industry classification) as the panel variable in our moment condition and thus control for all industry-specific characteristics that may also have an effect on the occupational mix of employment. Our estimated Poisson model looks as follows:

$$Y_{it} = \exp(\beta_1 \ln(\text{ImpInt}_{it}) + \beta_2 \ln(\text{ImpComp}_{it}) + \beta_3 \ln(\text{ExpInt}_{it})) * \exp(\delta' \ln(V_{it}) + \nu' \ln(Z_t) + \eta_i) + \epsilon_{it}. \quad (10)$$

The dependent variable,  $Y_{it}$ , measures the number of employees in industry  $i$  at time  $t$  attributed to a Blossfeld occupational group. We estimate equation (10) for each occupation (except agricultural occupations) included in the BHP.

The first independent variable is  $\text{ImpInt}_{it}$ , which measures the import intensity of industry  $i$  at time  $t$ , i.e. the (real) value of imported inputs. The second independent variable,  $\text{ImpComp}_{it}$ , includes import competition that is defined as the (real) value of imports of final goods.  $\text{ExpInt}_{it}$  stands for the (real) value of exports. The estimated coefficients  $\beta_1$ ,  $\beta_2$  and  $\beta_3$  show the effects on the employment of each occupational group if the exposure to international trade of the respective industry changes.  $V_{it}$  is a vector of control variables at the industry-level accounting for fur-

ther determinants that may affect the employment, such as the establishment size, activities in R&D, and the average share of high-skilled workers.  $Z_t$  is another vector of control variables at the macro-level. As it is not feasible to estimate our empirical model with year fixed-effects, i.e. a dummy variable for each of the 36 years, we include macro variables to control for year-specific effects. We use German GDP and the annual "Ifo Business Climate Index"<sup>22</sup> to account for any business cycle effects. Additionally, we include the overall education level of the German population and the size of the labor force to control for any systematic changes of the working population.<sup>23</sup> As the respective industry is the panel variable, the moment condition accounts for industry fixed-effects,  $\eta_i$ .  $\epsilon_{it}$  represents the error term.

To simplify the interpretation, we convert all right-hand side variables of equation (10) into the logarithmic form before we include them into the estimation. Therefore, the estimated coefficients can be interpreted as elasticities. Since we control for the industry size in terms of total employment, we are able to interpret the estimated employment effects in relative terms, i.e. the coefficients indicate whether the occupational mix of an industry shifts toward a certain occupational group or not.

Second, we calculate our empirical model at the establishment-level:

$$Y_{jit} = \exp(\beta_1 \ln(\text{ImpInt}_{it}) + \beta_2 \ln(\text{ImpComp}_{it}) + \beta_3 \ln(\text{ExpInt}_{it})) * \exp(\delta' \ln(V_{jit}) + \nu' \ln(Z_t) + \eta_j) + \epsilon_{jit}. \quad (11)$$

Here, we set the establishment identifier  $j$  as the panel variable and thus control for all unobserved establishment-specific characteristics. The empirical model represented by equation (11) is constructed in the same way as equation (10), but exploits the information of the BHP at the establishment-level. Hence, the dependent variable,  $Y_{jit}$ , measures the number of employees in each occupation in establishment  $j$  in industry  $i$  at time  $t$ , and  $V_{jit}$  is a vector of control variables at the establishment-level. Furthermore, we do not need to include industry fixed-effects, as the number of establishments changing their respective industry classification is negligible. Thus, the establishment fixed-effects,  $\eta_j$ , also control for any industry-specific fixed-effects. The remaining variables of equation (11) equal those of equation (10).

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<sup>22</sup>In order to use the annual "Business Climate Index", we aggregate the monthly "Business Climate Index" that is published by the "Ifo Center for Business Cycle Analysis and Surveys".

<sup>23</sup>The data for German GDP, the education level, i.e. the percentage share of German citizens with post secondary education, and the overall labor force are obtained from the German Federal Statistical Office.



### 4.3 Results

Table 2 presents the results from our estimations at the 3-digit industry-level represented by equation (10). The estimations include all control variables as well as industry fixed-effects. We estimate equation (10) for each Blossfeld occupational group except agricultural occupations. Hence, columns 1 to 11 of Table 2 show the effects of a change in import intensity, import competition, and export intensity on the employment in each occupation. The reported coefficients are elasticities. Hence, the coefficient of 0.0384 for the effect of an increase in export intensity on the number of technicians in a given industry reports that an increase in export intensity by 1% leads to an increase in the employment of technicians by 0.04%.

The estimations show various employment effects from the different trade channels. Import intensity, i.e. the import of inputs and intermediate products, has negative employment effects on all occupations except skilled administrative occupations and managers. The coefficients are significant for all service occupations except professions and all administrative occupations except skilled administration, indicating that especially the employees in lower-skilled service and administrative occupations suffer most from an increase in import intensity. These results support the literature on offshoring that finds negative employment effects from outsourcing, especially for employees with less complex tasks (e.g. Hogrefe (2013)). However, we cannot identify a negative employment effect from offshoring on (low-skilled) production occupations.

In case of import competition, i.e. the import of goods that compete with final goods of domestic suppliers, the results provide evidence that the employees in most occupations suffer from a more competitive environment. The employment effects are negative for all occupations except unskilled manual, service professions, and managers. Significance is displayed for technicians, unskilled services, and all administrative occupations except managers. Moreover, the negative effects of import competition on the employment in unskilled service occupations and in unskilled administrative occupations are substantially larger than the effects of import intensity. These findings are also in line with the literature that finds job losses due to increased competition with imported goods (e.g. Biscourp & Kramarz (2007) and Autor, Dorn & Hanson (2013)).

Table 2: Employment Effects of International Trade (3-digit Level), 1975-2010

<b>Fixed-Effects Poisson Model (GMM)</b>											
<b>Dependent Variable:</b>	<b>Production Occupations</b>				<b>Service Occupations</b>				<b>Administration Occupations</b>		
	Unskilled manual	Skilled manual	Technicians	Engineers	Unskilled services	Skilled services	Semi-professions	Professions	Unskilled admin.	Skilled admin.	Managers
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Import Intensity	-0.0086 (0.0109)	-0.0166 (0.0186)	-0.0024 (0.0093)	-0.0109 (0.0101)	-0.0417** (0.0171)	-0.0505* (0.0263)	-0.0703** (0.0339)	-0.0162 (0.0270)	-0.0811*** (0.0147)	0.0020 (0.0051)	0.0494** (0.0196)
Import Competition	0.0019 (0.0197)	-0.0111 (0.0177)	-0.0457*** (0.0124)	-0.0073 (0.0085)	-0.1223*** (0.0323)	-0.0614 (0.0470)	-0.0717 (0.0637)	0.0087 (0.0247)	-0.2480*** (0.0578)	-0.0362*** (0.0113)	0.0347 (0.0226)
Export Intensity	0.0069 (0.0202)	-0.0123 (0.0209)	0.0384*** (0.0129)	0.0210 (0.149)	0.0931*** (0.0291)	0.0749* (0.0441)	0.0987 (0.0627)	-0.0135 (0.0342)	0.2332*** (0.0582)	0.0346*** (0.0127)	-0.0480** (0.0242)
Other Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs.	3.094	3.094	3.094	3.094	3.094	3.094	3.094	3.094	3.094	3.094	3.094

Notes: Clustered standard errors (by industry) in parentheses, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

For export intensity, i.e. the export of goods by domestic establishments, we find positive signs for the employment effects for all but three occupations. The coefficients for technicians, unskilled services, skilled services, as well as unskilled and skilled administrative occupations are positive and significant; only for managers, the impact is negative and significant. Thus, it seems that employees in lower skilled occupations gain from an increase in exports. The employment effect of export intensity on the employment in unskilled administrative occupations is considerably larger than the effect of import competition.

Table 3 presents the results from the regression model estimated at the establishment-level according to equation (11). The estimation strategy and column interpretation is identical to Table 2 with the difference that the employment of each occupational group is now observed at the establishment-level. Hence, the coefficient of 0.0448 for the export intensity effect on the number of technicians, for example, reports that an establishment will increase the number of technicians by 0.04% if the industry it belongs to experiences an export intensity growth of 1%.

Compared to the industry-level estimation, the establishment-level estimations only show few significant employment effects from the different channels of international trade. To a great extent, the signs of the coefficients are unchanged, implying an employment change in the same direction as before. The estimated coefficients, however, lose significance. This most likely has to do with the fact that trade information is measured at the industry-level, whereas the employment is measured at the establishment-level. Additionally, we now control for the substantial unobserved establishment heterogeneity.

Import intensity now shows a negative and significant impact on the employment of technicians and unskilled administrative occupations. Although the former group represents a high-skilled occupation, this result is in line with the literature that shows an increasing offshorability of high-skilled jobs (Baldwin & Robert-Nicoud (2007)). In contrast, the employment effect on managers is positive and significant.

In case of the import competition, the results now show negative and significant employment effects on technicians and skilled administrative occupations. The coefficients on all other occupations are insignificant. The estimation for the export intensity at the establishment-level shows that technicians benefit from increasing exports, whereas the employment of managers decreases, which is in line with Mauron, Thesmar & Koenig (2002), but contradicts Caliendo & Rossi-Hansberg (2012).

Table 3: Employment Effects of International Trade (Establishment-Level), 1975-2010

<b>Fixed-Effects Poisson Model (GMM)</b>											
<b>Dependent Variable:</b>	<b>Production Occupations</b>				<b>Service Occupations</b>				<b>Administration Occupations</b>		
	Unskilled manual	Skilled manual	Technicians	Engineers	Unskilled services	Skilled services	Semi- professions	Professions	Unskilled admin.	Skilled admin.	Managers
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Import Intensity	-0.0031 (0.0064)	-0.0055 (0.0170)	-0.0140** (0.0067)	-0.0130 (0.0126)	-0.0065 (0.0112)	0.0121 (0.0179)	0.0097 (0.0207)	0.0230 (0.0278)	-0.0280** (0.0115)	-0.0023 (0.0038)	0.0522** (0.0215)
Import Competition	-0.0126 (0.0201)	-0.0176 (0.0231)	-0.0398* (0.0208)	-0.0050 (0.0113)	0.0028 (0.0222)	0.0050 (0.0833)	-0.0140 (0.0770)	0.0101 (0.0287)	-0.0150 (0.0257)	-0.0314** (0.0140)	0.0382 (0.0279)
Export Intensity	0.0207 (0.0254)	0.0013 (0.0305)	0.0448* (0.0269)	0.0256 (0.0214)	-0.0244 (0.0248)	-0.0177 (0.1022)	0.0344 (0.0862)	-0.0444 (0.0422)	0.0291 (0.0303)	0.0300* (0.0179)	-0.0820* (0.0488)
Other Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Establishment Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs.	379.805	379.805	379.805	379.805	379.805	379.805	379.805	379.805	379.805	379.805	379.805

Notes: Clustered standard errors (by industry) in parentheses, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

In summary, we find evidence at the industry-level that an increase in import intensity and in import competition decreases the employment in almost all occupations, whereas the employment increases in almost all occupations if export intensity increases. However, the estimations provide no evidence that international trade is a driving force behind the substantial employment decline in unskilled and skilled production occupations that is depicted in Table 1.<sup>24</sup> At the establishment-level, we find that the three channels of international trade only affect the employment of a few occupations although the signs of the coefficients are in line with the estimations at the industry-level. Mostly administrative occupations and technicians show significant employment effects. As discussed before, these results may have three causes: first, employment effects might become insignificant if we account for establishment heterogeneity by using establishment-fixed effects as well as control variables at the establishment-level. Second, our estimated coefficients may be mostly insignificant because of level differences. While the employment of the respective occupation and most of the control variables are reported at the establishment-level, the trade variables are measured at the 3-digit industry-level. Third, there might be changes in the occupational structure of firms due to international trade we cannot identify, since we only observe single establishments, not firms, which may have more than one establishment.

## 5 Conclusion

In this paper, we build on the fact that rather little empirical research has been conducted to investigate how trade openness impacts the occupational mix of manufacturing firms.

We identify three different trade channels: import intensity, import competition, and export intensity. To investigate the employment effects of these three channels, we match the BHP with UN Comtrade data by using a new matching approach. We take the input and output structure of the German manufacturing sector into account and allocate the trade flows accordingly.

Our stylized facts highlight the change of the employment structure of manufacturing establishments. To identify the relationship between the three channels of international trade and the employment in different occupations, we apply a fixed-effects Poisson model that especially accounts for the substantial individual

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<sup>24</sup>Thus it mostly might be skill-biased technological change and not international trade that explains job losses in low-skilled occupations. See for instance Katz & Autor (1999) and Acemoglu & Autor (2011) for an overview.

heterogeneity of industries and establishments. We estimate our empirical model both at the industry-level and at the establishment-level using industry fixed-effects or establishment fixed-effects, respectively.

Our results at the industry-level indicate that increasing import intensity and import competition lead to decreasing employment, whereas rising export activities increase employment. The employees in unskilled and skilled service occupations suffer from an increase in imports of intermediate products. Hence, increasing imports contribute to the decline in employment of these two occupations displayed in Table 1. In contrast, employees of the same occupational groups benefit most from an increase in exports. However, our estimations cannot identify international trade as a driving force behind the substantial employment decline in unskilled and skilled production occupations described in Table 1. If we estimate our empirical model at the establishment-level, our results suggest that only the employment of few occupations is affected by changes in international trade. The estimated coefficients lose significance, which is most likely due to level differences between the dependent variable and the independent variables and the inclusion of establishment fixed-effects. Furthermore, we are not able to identify changes in the occupational structure of firms, since we only observe single establishments.

Thus, a natural step for future research would be to check to what extent our results can be confirmed with a firm-level data set including activities in international trade.

## 6 Appendix

### Appendix 1:

#### Structure of employees by Blossfeld occupational groups

(Source: Blossfeld (1987), Table 1: Classification of Occupations)

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Name of Occupational Group	Description of Occupational Group	Examples
<b>Production</b>		
Unskilled manual occupations (EMB)	All manual occupations that showed at least 60 percent unskilled workers in 1970	Miners, rock breakers, paper makers, wood industry occupations, printing industry occupations, welders, unskilled workers, road and railroad construction workers
Skilled manual occupations (QMB)	All manual occupations that showed at most 40 percent unskilled workers in 1970	Glassblowers, bookbinders, typesetters, locksmiths, precision instrument makers, electrical mechanics, coopers, brewers
Technicians (TEC)	All technically trained specialists	Machinery technicians, electrical technicians, construction technicians, mining technicians
Engineers (ING)	Highly trained specialists who solve technical and natural science problems	Construction engineering, electrical engineers, production designers, chemical engineers, physicists, mathematicians

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## Appendix 1 cont'd:

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Name of Occupational Group	Description of Occupational Group	Examples
<b>Service</b>		
Unskilled services (EDB)	All unskilled personal services	Cleaners, security guards
Skilled services (QDB)	Essentially order and security occupations as well as skilled service occupations	Locomotive engineers, registrars
Semiprofessions (SEMI)	Service positions which are characterized by professional specialization	Interpreters, educators
Professions (PROF)	All liberal professions and service positions which require a university degree	Statisticians, economists, social scientist
<b>Administration</b>		
Unskilled commercial and administrative occupations (EVB)	Relatively unskilled office and commerce occupations	Postal occupations, office hands, typists
Skilled commercial and administrative occupations (QVB)	Occupations with medium and higher administrative and distributive functions	Credit and financial assistants, foreign trade assistants, data processing operators, book-keepers, goods traffic assistants
Managers (MAN)	Occupations which control factors of production as well as functionaries of organizations	Managers, business administrators, deputies, CEOs

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