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Quality Upgrading, Skill Demand and International Trade: The Case of German Manufacturing

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Quality Upgrading, Skill Demand and International Trade: The Case of German Manufacturing

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Abstract

The present paper contributes to the ongoing debate about how international trade can affect the demand for skills in industrial countries by estimating the impact of quality competition on the relative demand for low skilled workers in German manufacturing between 1995 and 2004. Results reveal a statistically significant negative effect albeit relatively small in size with quality competition accounting for approximately 5% of the overall decline in low skilled workers' wage bill share. This effect entirely stems from quality competition with other advanced countries. The influence of trade in different qualities with newly industrializing economies is negligible.

Keywords: international trade, quality differentiated products, labour demand

JEL classification: C23, F16, J23

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1 Introduction

During the last decades, world trade patterns have changed dramatically. At the same time, the position of low skilled workers in Germany and many industrialized countries deteriorated steadily. Very soon, both phenomena were linked with each other and resentment has been rising among the public against international trade and, in particular, the integration of newly emerging markets into the world economy. Until today, however, there is no consensus about the contribution of international trade to the large and well documented skill-upgrading of employment that many industrialized countries experienced.

Earlier empirical studies in this field of research primarily concentrated on separating the impact of international trade on the demand for skills from the effect of skill-biased technical change. Most studies concluded that trade plays some role but is not the driving force behind the deteriorating labour market position of low skilled employees in advanced countries. Instead, more weight has been attributed to the impact of technical change (e.g. Katz and Murphy, 1992; Berman et al., 1994 and 1998). One reason for this conclusion has been the following observation: The employment shift away from low skilled workers has rather been the consequence of a decrease in the share of low skilled labour within industries than a decline of industries predominantly employing low skilled workers and an expansion of industries with a large share of skilled workers. Since the former effect was ascribed to technical change and the latter to international trade, skill-biased technical change was considered to be primarily responsible for the labour market outcome of low skilled employees (see Berman et al., 1998; and Geishecker, 2006; for Germany during the 1970s and 1990s respectively).

In the middle of the 1990s, international outsourcing was introduced as one alternative explanation to skill-biased technical change, as it was assumed to affect the employment structure within industries by shifting the demand away from low skilled workers (Feenstra and Hanson, 1995 and 1996). However, the view that outsourcing adversely affects low skilled workers has been challenged by more recent theoretical contributions (Arndt, 1997 and 1999; Venables, 1999; Jones and Kierzkowski, 2001; Kohler, 2004). For Germany, empirical research on the linkage between outsourcing and the relative demand for low skilled workers yields ambiguous results. According to Geishecker (2004, 2006), outsourcing has contributed to the shift from low skilled towards high skilled workers in German manufacturing. Ochsen and Welsch (2005) also record this substitution effect of outsourcing. However, they state that this effect was compensated by a growth in exports of low skilled labour intensive products. The study leaves unclear whether, in total, low skilled workers gain or lose from outsourcing.

International trade might affect the demand for skills through further channels. One issue that has largely been neglected in empirical analysis is that different kinds of trade flows may provoke different reactions on the labour market. In general, the literature distinguishes between three categories of trade flows which are each assumed to provoke different reactions on the labour market: inter-industry trade (i.e. one-way trade), horizontal intra-industry trade (HIIT) (i.e. two-way trade in products of the same product category with the same quality but different product attributes such as color or design) and vertical intra-industry trade (VIIT) (i.e. two-way trade in products of the same product category but with different quality levels).

The impact of each of these trade flows on the labour market in industrial countries after trade liberalization is expected to be as follows: an expansion of inter-industry trade is assumed to trigger the reallocation of factors between industries. Industries producing with a relatively high share of low skilled labour are supposed to decline (e.g. clothing), whereas branches using a relatively high amount of skilled labour (e.g. machinery) expand. In contrast, an increase in intra-industry trade (IIT) is concomitant with factor reallocation within industries. However, since traded goods are produced with similar factor intensity, a rise in HIIT is considered to have no significant effect on factor demand. This is ascribed to the small amount of net exchange of labour with different skill levels involved in transactions. Yet, there may be a sizable impact of VIIT on the demand for skills since the production of quality differentiated products requires different factor intensities. In fact, an expansion in VIIT is assumed to lead to the specialization on skill intensive, high quality niches in the country well endowed with physical and human capital (e.g. made-to-measure suits), while the production of low skilled intensive, lower quality varieties shrinks (e.g. Falvey, 1981; Falvey and Kierzkowski, 1987). Since the persistent need for innovation and product quality upgrading also increases the requirement for professional and technical flexibility, the demand for qualified and highly productive workers rises whereas the labour market position of less qualified employees deteriorates. Consequently, a rise in VIIT causes similar reallocative effects as an increase in inter-industry trade: it reduces the demand for low skilled workers. However, rather than changing the labour composition of different skills between industries, VIIT is supposed to affect labour composition within industries, hence provoking similar reallocative effects as skill-biased technical change and international outsourcing.

Using industry-level data, the present paper investigates empirically to what extent quality competition and Germany's subsequent specialization on high quality niches has favoured skill-upgrading in German manufacturing between 1995 and 2004. The paper contributes to the existing literature on trade and employment in several ways: First, it provides some evidence on the linkage between quality competition in international trade and the demand for skills in industrial countries. This issue has received little attention in empirical analysis so far. Since Germany is strongly engaged in international trade and commonly characterized as a country with a great importance of product quality, it provides an interesting case study. Second, it is explicitly dealt with the potential labour market impact of trade between advanced countries. To the best knowledge of the author, this issue has not been considered in previous empirical investigations that primarily concentrate on the effect of trade with less developed countries.

The effect of trade in different qualities on the demand for low skilled workers in Germany is found to be negative and statistically significant. However, it is relatively small in magnitude with quality competition accounting for approximately 5% percent of the overall decline in low skilled workers' wage bill share. The impact of quality competition on the skill structure of employment primarily stems from trade with advanced countries. On the other hand, the exchange of quality differentiated products with newly industrializing countries has no effect on factor intensity.

The remainder of the paper is structured as follows: Chapter 2 examines the process of skill-upgrading in German manufacturing in more detail. Chapter 3 analyses the importance of quality in German foreign trade. In Chapter 4, the impact of VIIT on the demand for skills is estimated empirically. Chapter 5 discusses the empirical findings. Chapter 6 concludes with a summary of the most important insights.

2 Skill-upgrading in German manufacturing: within or between industries?

Since the late 1970s, the labour market position of low skilled workers in Germany started to worsen steadily. At the beginning, this has rather been manifested in a disproportionately growing unemployment rate of this skill group than in an increase in wage inequality (e.g. Reinberg and Hummel, 2007). The worsening labour market position of low skilled workers was mainly ascribed to institutional rigidities caused by the power of labour unions in the system of central wage bargaining and by specific labour market regulations (e.g. Blau and Kahn, 1996 and 2002; Fitzenberger, 1999; Fitzenberger et al., 2001; Prasad, 2004; Möller, 2005). Since the mid-1990s, the decrease in the relative demand for low skilled workers has also been reflected in terms of relative remuneration as the rising wage inequality across skill groups suggests. In addition, low skilled workers have also lost in real terms (e.g. Kohn, 2006; Dustman et. al, 2009; Gernandt and Pfeiffer, 2007).

Berman et. al. (1998) and Geishecker (2006) examined the process of skill-upgrading in more detail for German manufacturing for selected years during the 1970s and 1990s respectively. They concluded that the shift away from low skilled to high skilled workers has been mainly due to within-industry changes. In both studies, the overall decline in low skilled workers' share in total employment has been divided into two components: one that reflects the shift of low skilled labor demand across industries (the between component) and another one associated with the shift from low skilled towards high skilled labour within industries (the within component) as suggested by Berman et al. (1994):

$$\Delta S^{LS} = \sum_{i=j}^{n} \Delta h_i \overline{S}_i^{LS} + \sum_{i=j}^{n} \Delta S_i^{LS} \overline{h}_i \qquad (1)$$

where ΔS^{LS} is the overall change in the share of low skilled labour, $S_i^{LS} = L_i^{LS} / L_i$ denotes the proportion of low skilled workers in industry i and $h_i = L_i / L$ represents the employment share of industry i in total manufacturing employment. An overbar indicates the average over the time period under consideration. The first term on the right hand side refers to the shift of employment shares between industries and the second term is attributed to the shift within industries.

In the present paper, similar analysis for German manufacturing has been applied including a more recent time period, namely 1995 to 2004.[1] Data on industry employment was obtained from the German Federal Statistical Office where data is provided for the broad categories of production and non-production workers. Thereby, production and non-production workers are

[1] The calculation was done without the *tobacco, coke and refined petroleum* as well as the *recycling industry*. These industries are also excluded from econometric analysis in section 4.

supposed to proxy low skilled workers and high skilled workers respectively. Obviously, this distinction is only a crude approximation to the differentiation between low skilled and high skilled labour. Furthermore, it is based on the assumption that all production workers are low skilled and all non-production workers are high skilled. In fact, some production work might be highly skilled (e.g. that of a production manager) and some non-production work might be completely unskilled (e.g. that of a doorman). Nonetheless, it should be unquestionable that the share of genuinely low skilled work is much higher among manual jobs than among non-manual jobs. Furthermore, this broad separation of skill groups is very often applied in the literature (e.g. Berman et. al., 1994 and 1998).

The results of the decomposition analysis for the period between 1995 and 2004 are presented in Table 1. The message of the table is quite unambiguous: Between 1995 and 2004, the process of skill-upgrading continued to persist and the within effect has been very large. During that time, production workers' share in manufacturing was reduced by 2.69 percentage points. This reduction has been due to a substantial fall of production workers' share within industries (-2.91 percentage points) which was marginally compensated by a shift towards manual labour intensive industries as the positive between component suggests (+0.22 percentage points). Hence, the results found by earlier studies can basically be confirmed.

If the same calculation is done for production workers' share in total wage bill instead of their share in employment, similar results are obtained. In doing so, it can be accounted for the observation that the decline in the relative demand for less skilled workers in Germany has been reflected in both declining relative employment and relative wages during that time. Between 1995 and 2004, production workers' share in the wage bill decreased by 3.45 percentage points, due to a within-industry shift of -3.81 percentage points which was slightly compensated by a between-industry shift of +0.36 percentage points.

3 Vertical intra-industry trade and its incidence in German foreign trade

In order to gain information on the importance and development of VIIT in German foreign trade, it is necessary to separate inter-industry and intra-industry trade flows (i.e. one-way and two-way trade) in a first step and VIIT from HIIT in a second step. Table 2 provides an overview over the categorization of trade flows and the methods used to segregate them from each other. To distinguish between inter-industry and intra-industry trade (IIT), the methodology suggested by Fontagné and Freudenberg (1997) and Fontagné et al. (1998) has been adopted. Hence, the bilateral trade flow of a specific commodity is categorized as intra-industry trade if the value of the minority flow exceeds 10% of the value of the majority flow. To decompose intra-industry trade into VIIT and HIIT, information on product quality is required. Since trade data in general do not contain specific information on the quality of the products traded, unit values are usually used to proxy quality (Abd-el-Rahman, 1991). The unit value of a product is thereby computed by dividing the import (or export) value through its import (or export) quantity. Assuming that the difference between export and import unit values for a product reflects the differences in quality between the exports and imports of the respective commodity, industry trade is then categorized either as VIIT or as HIIT. In the literature, intra-industry trade is defined as vertical if relative export and import unit values differ by more than +/- 15%. Otherwise it is considered to be horizontal (e.g. Greenaway et al., 1994 and 1995; Fontagné and Freudenberg, 1997; Fontagné et al., 1998).[2]

According to the above described methodology, the evolution of German foreign trade structure has been analyzed for the period between 1995 and 2004. Data on German trade flows have been taken from Comext-Database (EUROSTAT) where annual data is provided on a disaggregated eight-digit level (Combined Nomenclature). This is the lowest possible level of aggregation available. The investigation covers more than 10,000 manufacturing products and considers trade with 45 major German trading partners. These 45 partner countries consist of 20 advanced countries, primarily member countries of the European Union, and 25 newly emerging markets from South East Asia, Latin America and Eastern Europe. The distinct countries are listed in Table 5. Manufacturing trade with these countries accounts for around 90% of total German manufacturing trade.

Once the data on trade flows has been segregated into the three types using bilateral trade data on values and unit values, this data has been aggregated to a two-digit industry level using the (eight-digit level) industry value of exports and imports as weights. When analyzing the development of trade structures in German manufacturing between 1995 and 2004, several insights emerge. Table 3 summarizes the share of the distinct trade category in total trade for

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[2] Obviously, the level of VIIT share in total trade of industry *i* depends on the range between export and import unit values used to distinguish between HIIT and VIIT. The choice of the range, in turn, is thereby exposed to some kind of arbitrariness. In addition to the range of +/- 15%, Greenaway et al. (1994, 1995) suggest an alternative range of +/- 25%.

German manufacturing in 1995 and 2004. Apparently, intra-industry in general plays an important role in German manufacturing trade. In 1995, the share of two-way trade in total trade was over 50%. Within intra-industry trade, trade in different qualities (i.e. VIIT) is more important than trade in similar qualities (i.e. HIIT). From 1995 to 2004, the share of intra-industry trade increased slightly at the expense of one-way trade due to a rise in VIIT.

Data furthermore suggests that the relative importance of inter-industry and intra-industry trade crucially depends on the development level of the partner country. Trade relationship between Germany and other advanced countries is largely of an intra-industry nature with a share of two-way trade of over 60%. On the contrary, trade with emerging markets is still dominated by inter-industry trade although the share of intra-industry trade with these countries has been increasing steadily since 1995, exceeding 30% in 2004. Within intra-industry trade, VIIT plays an important role, irrespective of the development level of Germany's trading partner. Hence, the exchange in different qualities does not only play a role in German trade relationships with newly emerging markets but also with other advanced countries. This finding is in line with other empirical evidence on the development of trade patterns among advanced countries as well as among advanced economies and emerging markets (e.g. Fontagné et al., 2006).

When analyzing trade patterns for particular manufacturing industries, the data indicates that the share of trade in quality differentiated products in total trade differed across industries with respect to their importance and developed uneven across industries between 1995 and 2004. Both the relative importance and the development of VIIT depends on whether German trade with emerging markets or with advanced partners is considered. Figure 1 shows the evolution of German trade patterns with all 45 partner countries included in the analysis for 20 selected industries of the manufacturing sector. In Figure 2 and 3, the development of trade patterns in these industries is illustrated separately for German trade with advanced countries and newly industrializing economies respectively.

Although the share of trade with advanced countries decreased slightly between 1995 and 2004, it still amounted to around 75% of overall German trade in 2004. Consequently, the pattern of trade in most industries is determined by trade with these countries as the comparison of Figure 1 and 2 suggests. Figure 2 shows that German trade patterns with advanced nations turned out to be relatively stable in a large number of industries between

1995 and 2004. Furthermore, German trade relationships with less developed countries largely appear to be of an intra-industry type with VIIT as the dominant form of two-way trade. Regarding level and development of VIIT, particularly high and fairly stable levels (of more than 50%) could be observed in industries such as wearing apparel, printing and publishing, rubber and plastics, office and computing, electrical machinery as well as precision instruments. Some industries also experienced a significant expansion of trade in qualities, ranging from increases of around 9 percentage points in the textile industry, the communication sector and the production of food and beverages to over approximately 13 percentage points in the leather and footwear industry, and up to 34 percentage points in the production of transport equipment other than motor vehicles.

Compared to trade with advanced countries, traditional one-way trade still dominates German trade relationships with newly industrializing countries in most sectors. However, Figure 3 depicts that German trade patterns with these countries evolved very dynamically. For a large number of manufacturing industries the share of VIIT in total trade increased nearly constantly between 1995 and 2004 at the expense of inter-industry trade. This reflects the impressive catching-up process of these countries' within product groups. Particularly strong and nearly constant increases of VIIT could be observed in sectors such as machinery, precision instruments or transport equipment with the share of VIIT rising by more than 10 percentage points, reaching levels of over 30% in total trade. Apparently, emerging market economies are gradually entering those markets which had been prior domains of industrial countries. Despite these remarkable changes, though, it should be kept in mind that the share of trade with these countries in total German manufacturing trade is still relatively small. Between 1995 and 2004, it grew from approximately 19% to around 25%.[3]

Summing up, the data suggests that trade in quality matters in German trade with both advanced partner countries and newly emerging markets. Chapter 2 has shown that there is a need to focus on factors that affect the employment structure within industries when explaining the change in the relative demand for skills in German manufacturing. In the following, an empirical analysis is conducted to find out whether the specialization of German

[3] Using an alternative range of +/- 25% between export and import unit values to distinguish between VIIT and HIIT as proposed by Greenaway et al. (1994, 1995) basically yields the same results for the analysis conducted in this chapter.

firms on first-rate quality products is one of the forces behind the process of skill-upgrading in German manufacturing.

4 Trade in qualities and skill demand in German manufacturing

Despite the importance of product quality in international trade, empirical studies examining its impact on the demand for skills in industrial countries are scarce.[4] Ito and Fukao (2004) study the influence of trade in vertically differentiated products on the skill structure of employment in Japanese manufacturing between 1988 and 2000. They provide empirical evidence for a positive and statistically significant effect of Japanese VIIT with newly industrializing Asian economies on intra-industry skill-upgrading. However, the significant positive impact could only be observed when skilled workers were defined as employees with professional and technical or managerial and administrative occupations. When skilled employees were classified as non-production workers, the effect of VIIT was found to be statistically insignificant.

To quantify the impact of VIIT on the relative demand for low skilled workers in German manufacturing, the present study employs a similar translog cost function approach based on the work of Berman et al. (1994) and Feenstra and Hanson (1996a,b). An arbitrary aggregated production function for each industry i is assumed:

$$Y_i = Y(L_i^{LS}, L_i^{HS}, K_i, T_i) \quad (2)$$

where Y_i denotes industry i's output that is produced with a range of homogenous inputs. L_i^{LS} and L_i^{HS} denote the amount of low skilled labour and high skilled labour respectively. K_i represents the capital stock of industry i and T_i is a time variable that is included to allow the structure of production to vary over time. Basically, T_i can be interpreted as a technology parameter that captures changes in technical efficiency.

[4] The majority of empirical investigations dedicated to trade in different qualities is oriented towards a better understanding of its determinants (e.g. Greenaway et al., 1994 and 1995, Schott, 2004, Hummels and Klenow, 2005, Hallak, 2006).

It is assumed that there are two variable factors of production, namely high skilled and low skilled workers. Capital is considered as a quasi-fixed input, implying that it is fixed in the short run, but may differ from its long-run equilibrium. If it is further assumed that the isoquants of the production functions are convex and that firms seek to maximize profits, for each industry, a dual variable unit cost function exists:

$$CV_i = CV(Y_i, W_i^{LS}, W_i^{HS}, K_i, T_i) \tag{3}$$

where CV_i reveals variable cost. W_i^{LS} and W_i^{HS} represent the wage rates for low skilled and high skilled workers respectively. For an empirical implementation, an appropriate functional form of the cost function in (3) has to be specified. Thereby, the variable cost function is approximated by a translog cost function with variable and quasi-fixed input factors as suggested by Brown and Christensen (1981):

$$\begin{aligned}
\ln CV_i = {} & \alpha_0 + \alpha_Y \ln Y_i + \frac{1}{2}\alpha_{YY}(\ln Y_i)^2 + \alpha_K \ln K_i + \frac{1}{2}\alpha_{KK}(\ln K_i)^2 + \alpha_{LS} \ln W_i^{LS} + \alpha_{HS} \ln W_i^{HS} \\
& + \frac{1}{2}\alpha_{LSLS}(\ln W_i^{LS})^2 + \frac{1}{2}\alpha_{LSHS} \ln W_i^{LS} \ln W_i^{HS} + \frac{1}{2}\alpha_{HSHS}(\ln W_i^{HS})^2 + \frac{1}{2}\alpha_{HSLS} \ln W_i^{HS} \ln W_i^{LS} \\
& + \alpha_{YLS} \ln Y_i \ln W_i^{LS} + \alpha_{YHS} \ln Y_i \ln W_i^{HS} + \alpha_{KLS} \ln K_i \ln W_i^{LS} + \alpha_{KHS} \ln K_i \ln W_i^{HS} + \alpha_{YK} \ln Y_i \ln K_i \\
& + \alpha_T T_i + \frac{1}{2}\alpha_{TT} T_i^2 + \alpha_{TY} T_i \ln Y_i + \alpha_{TK} T_i \ln K_i + \alpha_{TLS} T_i W_i^{LS} + \alpha_{THS} T_i W_i^{HS}
\end{aligned} \tag{4}$$

where $\alpha_{HSLS} = \alpha_{LSHS}$ is assumed for symmetry reasons. Cost minimization behaviour implies that the cost function is homogenous of degree one in prices which implies that, for a fixed level of output, total cost must rise proportionally when all prices increase proportionally. For this condition to hold, the following restrictions are imposed on equation (4):

$$\begin{gathered}
\alpha_{LS} = 1 - \alpha_{HS} \\
\alpha_{HSHS} + \alpha_{HSLS} = \alpha_{LSLS} + \alpha_{LSHS} = 0 \\
\alpha_{YLS} + \alpha_{YHS} = \alpha_{KLS} + \alpha_{KHS} = \alpha_{TLS} + \alpha_{THS} = 0
\end{gathered} \tag{5}$$

In a next step, an industry i's demand for low skilled workers can be obtained. According to Shephard's Lemma (1953), the partial derivative of the variable cost function with respect to the price of a certain variable factor yields the demand for this factor. Since the cost function is in logarithmic form, cost minimization delivers the share of this factor in total variable costs. Hence, we obtain the following factor share equation for low skilled workers:

$$\frac{\partial \ln CV_i}{\partial \ln W_i^{LS}} = \frac{\partial CV_i}{\partial W_i^{LS}} \frac{W_i^{LS}}{CV_i} = \frac{L_i^{LS} W_i^{LS}}{CV_i} = WS_i^{LS} \qquad (6)$$

with WS_i^{LS} representing the cost share of low skilled workers in total wage bill of industry i. Differentiating (4) with respect to the wage of low skilled workers yields:

$$\begin{aligned} WS_i^{LS} &= \alpha_{LS} + \alpha_{LSLS} \ln W_i^{LS} - \alpha_{LSLS} \ln W_i^{HS} + \alpha_{YLS} \ln(Y_i) + \alpha_{KLS} \ln(K_i) + \alpha_{TLS} T_i \\ &= \alpha_{LS} + \alpha_{LSLS} \ln\left(\frac{W_i^{LS}}{W_i^{HS}}\right) + \alpha_{YLS} \ln(Y_i) + \alpha_{KLS} \ln(K_i) + \alpha_{TLS} T_i \qquad (7) \end{aligned}$$

with W_i^{LS} / W_i^{HS} denoting the relative wage rate of low skilled and high skilled workers in industry i. As already pointed out by Feenstra and Hanson (1996a, 1996b), including only factors derived from the traditional cost function might not capture all determinants influencing an industry's demand for low skilled labour. Therefore, the empirical application of the above mentioned model is enhanced by two further variables, namely an indicator for outsourcing activities of industry i as well as an indicator reflecting an industry i's pressure to upgrade product quality, i.e. VIIT:

$$\begin{aligned} WS_{it}^{LS} = \beta_0 + \beta_1 \ln\left(\frac{W_{it}^{LS}}{W_{it}^{HS}}\right) + \beta_2 \ln(Y_{it}) + \beta_3 \ln(P_{it}) + \beta_4 \ln(E_{it}) \\ + \beta_5 \ln(OUTS_{it}) + \beta_6 \ln(VIIT_{it}) + \beta_7 D_t + v_{it} \qquad (8) \end{aligned}$$

where t refers to specific years and the variable $OUTS_i$ reflects international outsourcing in industry i. $VIIT_i$ is the value of trade in quality differentiated products in industry i over industry i's shipments.[5] D_t is a set of year dummies which accounts for secular changes that are common to all industries and affect the demand for skills from one year to another (e.g. common macroeconomic effects, structural changes etc.), but are not explicitly modelled. The

[5] To fit the model better to the data, the variables measuring outsourcing ($OUTS_i$) and trade in quality differentiated products ($VIIT_i$) also enter regression in logarithmic form.

error term v_{it} accounts for unobserved factors that affect the demand for skills within industries. These unobserved factors might either vary over time and are then reflected in the idiosyncratic error u_{it} or might be constant over time and are than captured by an industry-specific time-constant error term a_i, hence $v_{it} = a_i + u_{it}$.

To capture the impact of technical progress expressed as T_i in (7), the capital variable (K_i) has been divided into two components, namely buildings and plants (P_i) and equipment (E_i). Thereby, the equipment variable (E_i) that comprises machinery and other assets (e.g. assets of an immaterial nature such as software programs) is supposed to capture the impact of technical change on production workers' share in the wage bill. The rationale behind this approach is that economic theory has attached great importance to the role of capital in technical change (e.g. Acemoglu, 2002). In fact, the capital stock provides essential information on the state of technology since many innovations are embodied in capital goods such as machinery. Furthermore, the skill bias of technical change is supposed to be closely linked to the mechanization of the production process as low skilled workers can easily be substituted for machines. The remaining industry-specific impact of technical change that is not absorbed by the equipment variable is captured by the industry specific error term, v_{it}.[6]

Estimating equation (8) might cause endogeneity problems since relative wage rates (W_i^{LS} / W_i^{HS}) do not necessarily have to be exogenous. In fact, wages and the relative demand for low skilled labour might be determined simultaneously which, in turn, implies biased coefficients. This issue can hardly be excluded completely in spite of German manufacturing industries' wage coordination (Geishecker, 2004). Thus, following previous studies (e.g. Berman et al., 1994) relative wages are omitted from the regression. If it is assumed that the relative price of low skilled to high skilled labour does not vary across industries, the exclusion of relative wages from regression will only affect the constant term (Berman et al., 1994). Alternatively, annual changes in the wage levels faced by all industries might be absorbed by the time dummies.

[6] Additionally, the constant term and the set of time dummies capture changes in technical efficiency that are common to all industries.

Equation (8) is estimated applying first difference estimation. Differencing (8) after having dropped the relative wage variable yields the following model:

$$\Delta WS_{it}^{LS} = \beta_0^* + \beta_1^* \Delta \ln(Y_{it}) + \beta_2^* \Delta \ln(P_{it}) + \beta_3^* \Delta \ln(E_{it}) + \beta_4^* \Delta \ln(OUTS_{it}) + \beta_5^* \Delta \ln(VIIT_{it}) + \beta_6^* D_t + \varepsilon_{it} \qquad (9)$$

where Δ denotes the change from t-1 to t and $\varepsilon_{it} = \Delta u_{it}$.[7] Equation (9) is estimated using feasible generalized least squares estimation technique (FGLS) to obtain heteroskedasticity-consistent standard errors. [8]

When estimating (9), the coefficient of the variable denoting industry's production value (Y_i) is expected to have a positive sign, assuming that the demand for manual workers and hence their share in total wage bill rises with an increase in output. Since capital, in general, is supposed to be more complementary to high skilled (i.e. non-production) workers than to low skilled (i.e. production) workers, the coefficient of capital stock should have a negative sign. This hypothesis which is commonly referred to as capital-skill complementary has been first formalized by Griliches (1969) and confirmed by a range of empirical studies (Hamermesh, 1986, 1993; Krusell et al. 2000; Duffy et al. 2004). However, measuring capital separately as plants (P_i) and equipment (E_i) might yield a more differentiated picture on the role of capital in affecting the skill structure of employment since the impact of both types of capital might differ. Whereas an increase in equipment (E_i), i.e. machines etc. is expected to adversely affect production worker (e.g. Acemoglu, 2002), the impact of an increase in buildings and plants is ambiguous from an empirical point of view (e.g. Berman et al., 1994) and, in addition, has not been theoretically elaborated. The sign of the coefficient of the outsourcing variable, $OUTS_i$, is also not clear cut from a theoretical point of view, as already mentioned before.

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[7] Even though the time dummies have been included in regression at the beginning, they have finally been dropped since none of them turned out to be statistically significant.

[8] The presence of heteroskedasticity has been detected with residuals tending to vary stronger for smaller industries. Thereby, the existence of heteroskedasticity has been tested applying a Breusch-Pagan/Cook-Weisberg test (Pindyck and Rubinfeld, 1998). Serial correlation and contemporaneous correlation, in turn, do not seem to be a problem in the FD model. In order to test for serial correlation, the procedure suggested by Wooldridge (2002) has been employed. To find out whether the residuals are correlated across entities, a Pesaran CD test (Pesaran, 2004) has been implemented.

Finally, an expansion of VIIT is perceived to reduce the share of production worker's wage bill in total wage bill, implying a negative coefficient for $VIIT_i$. To check for potential differences regarding the distributional impact of quality competition with industrial advanced and newly industrializing countries, German VIIT with both kinds of trading partners is considered separately in a second regression. Regarding VIIT with advanced economies, trade theory tells us relatively little about how an increase in VIIT might affect the skill structure of employment. In fact, the influence of trade between advanced countries on skill composition was considered to be negligible for a long time. This was justified by the assumption that trade between those countries largely consists of the exchange of varieties with similar quality, i.e. HIIT. The incidence of substantial exchange in different qualities nevertheless implies that German trade with other industrialized countries might affect low skilled workers' position on the labor market as well. However, it is not clear which country specializes on which quality segment when different qualities are traded bilaterally between countries that exhibit similar factor endowments. This makes it difficult to predict the consequences of a VIIT expansion for the labour market. Consequently, the effect of German VIIT with advanced countries on the relative demand for low skilled workers in Germany is an empirical question after all.

Last but not least, it is accounted for the possibility that the control variables' impact on the skill structure of employment might not be instantaneous by including one period lags of all variables in another regression.[9]

5 Results and discussion

Regression results are presented in Table 6 (regressions (a)-(d)). Analyzing the results yields the following insights: An increase in output has the expected positive effect on production workers' share in the wage bill. While the immediate impact is statistically significant, the lagged impact is insignificant. The effect of capital in the form of buildings or plants is ambiguous. Whereas the instant impact is positive, the delayed impact is negative. Both are not statistically significant. When measured as equipment, capital has always a negative coefficient and its immediate impact is statistically significant in nearly all regressions. The

[9] In the case of VIIT, two and three period lags have been introduced in regression at the beginning to consider that the process of restructuring within firms due to increased quality competition from abroad takes some time. Since none of them has been statistically significant, they have been dropped from regression.

lagged variable is never statistically significant. Although the coefficient of the outsourcing variable always has a negative sign, its impact on production workers' share in the wage bill is very small and mostly not statistically significant.

The coefficient for VIIT is negative and statistically significant for all regressions when the immediate impact is considered. Apparently, trade in quality differentiated products and hence the pressure to upgrade product quality plays some role in determining the relative demand for low skilled workers in Germany. When analyzing the effect of VIIT with respect to the development level of Germany's trading partners, results indicate that the impact of VIIT on production workers' wage bill share can entirely be attributed to quality competition with other advanced countries. The estimated coefficient of VIIT with industrialized countries is negative and statistically significant in all regressions. In contrast, the coefficient for German VIIT with newly emerging markets is very small and always insignificant. This implies that even though these countries have started to produce more complex and sophisticated goods, the quality they produce is most likely still too low to exhibit substantial competitive pressure on German firms.

Using the estimated coefficients of VIIT, further calculations suggest that the expansion of VIIT has delivered a maximum contribution to the decline in the production workers' cost share of approximately 5% between 1995 and 2004. Therefore, it can be concluded that trade in different qualities appeared to be of relatively small economic importance in determining the overall decline in the demand for production workers in German manufacturing during that time. The decrease in production workers' wage bill share that is not explained by changes in VIIT can, at least partly, be ascribed to the automatization of the production process which, in turn, is closely linked to technical change.

The robustness of the results has been tested with respect to the range between export and import unit values used to distinguish between HIIT and VIIT, running all regressions with an alternative range of +/- 25% (Greenaway et al., 1994, 1995). The results are also reported in Table 6 (regressions (e)–(h)). The findings regarding the statistical significance and magnitude of the variables included in regression do not change notably. The parameter of primary interest, i.e. the coefficient of VIIT, remains statistically significant even though it slightly decreases in size.

6 Conclusion

Quality competition has become an important determinant in German trade relationships. The aim of this paper was to find out whether Germany's specialization on top-quality products as a reaction to rising international competition within product groups has contributed to the observed skill-upgrading within German manufacturing industries by enhancing the need for the ability to be flexible and to adapt quickly to ongoing changes in international markets. Estimation results suggest that the rise of trade in quality differentiated products had a statistically significant negative impact on the relative demand for less skilled workers between 1995 and 2004. This impact, though, is relatively small in magnitude. Increased quality competition and the process of restructuring associated with it accounts for approximately 5% percent of the overall decline in production workers' wage bill share during that time. Results also indicate that there is no foundation for the fear that the tremendously catching-up of newly industrializing countries in terms of product quality has contributed to the increase in human capital intensity in the time period under consideration. Instead, the negative impact of VIIT on the relative demand for production workers can primarily be ascribed to quality competition with other advanced countries.

Appendix

Data

The econometric estimation is based on two-digit industry level data for 20 out of 23 German manufacturing industries, classified according to the WZ 2003 (which corresponds to the NACE Rev. 1.1). Three industries were excluded from analysis for the following reasons: the recycling industry due to a lack of data and the tobacco and the coke and refined petroleum industry as they have been identified as outlier industries. Due to data restrictions and systematic changes in the industry classification, econometric analysis is restricted to the period between 1995 and 2004. This yields a total number of 200 observations.

Data on industry payments and employment, has been taken from the German Federal Statistical Office where it is grouped into data for wage earners and salaried employees which roughly corresponds to the distinction between production and non-production workers (Fachserie 4, Reihe 4.1.1). The dependent variable that measures for each industry production workers' cost share in total wage bill is obtained by dividing wage payments through the sum of total wage and salary payments in the respective industry.

Annual data on industries' value of production in prices of 2000 has been taken from the German Federal Statistical Office (Fachserie 18, Reihe 1.4, own calculations). Annual averages of net capital stock measured in prices of 2000 are also provided by the German Federal Statistical Office (Fachserie 18, Reihe 1.4). Capital stock data can be obtained as an aggregate or separately as (i) buildings and plants and (ii) as equipment that comprises machinery and other assets (e.g. immaterial assets such as software programs).

To distinguish between two-way trade of products and the international division of production, international outsourcing is measured relying on the import content of intermediate consumption. The index used to measure outsourcing in the present econometric study is based on major preceding studies by Feenstra and Hanson (1996a, 1996b and 1999) and its modifications by Geishecker and Görg (2008). The outsourcing measure is based on the narrow concept of outsourcing and is calculated as the value of an industry's imported goods from the same industry abroad expressed as a share of the domestic industry's production value. Annual values of imported intermediate inputs in current prices are taken from the annual German input-output tables of national account data (Fachserie 18, Reihe 2). Data are adjusted to prices of 2000 using the price index for imported manufacturing goods (Fachserie 17, Reihe 8.1).

Data on trade flows are taken from of Comext-Database (EUROSTAT), where annual data are provided on a disaggregated eight-digit level (Combined Nomenclature). Data are not corrected for inflation as price indices are not available at such a disaggregated level. Apart from that, the interest is primarily in structural changes as reflected in the distribution of trade flows across sectors.

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Tables

Table 1: Decomposing the change in production workers' employment/wage bill share

Employment			Wage bill		
Total	Between	Within	Total	Between	Within
- 2.69	0.22	-2.91	- 3.45	0.36	- 3.81

Source: Author's calculations. Note: Data on wages and employment comprise 20 German manufacturing industries and have been obtained from the German Federal Statistical Office. The time period under observation is 1995 to 2004.

Table 2: Categorization of trade flows

Type	Degree of trade overlap	Disparity of unit value
One-way trade (OWT)	$\frac{Min(X_{kk'jt}, M_{kk'jt})}{Max(X_{kk'jt}, M_{kk'jt})} \leq 0.1$	Not applicable
Horizontal intra-industry trade (HIIT)	$\frac{Min(X_{kk'jt}, M_{kk'jt})}{Max(X_{kk'jt}, M_{kk'jt})} > 0.1$	$\frac{1}{1.15} \leq \frac{UV^X_{kk'jt}}{UV^M_{kk'jt}} \leq 1.15$
Vertical intra-industry trade (VIIT)	$\frac{Min(X_{kk'jt}, M_{kk'jt})}{Max(X_{kk'jt}, M_{kk'jt})} > 0.1$	$\frac{UV^X_{kk'jt}}{UV^M_{kk'jt}} < \frac{1}{1.15}$ or $1.15 < \frac{UV^X_{kk'jt}}{UV^M_{kk'jt}}$

Source: Fontagné and Freudenberg (1997); author's illustration. Note: $X_{kk'jt}$ is the value of declaring country k's exports of product j to partner country k' and $M_{kk'jt}$ the value of country k's imports of product j from country k’ at time t; $UV^{X}_{kk'jt}$ is the average unit value of country k’s exports of product j to country k’ and $UV^{M}_{kk'jt}$ the average unit value of country k ’s imports of product j from economy k’ at time t.

Table 3: Trade patterns in German manufacturing between 1995 and 2004 (in %)

	1995				2004			
Trading partner	OWT	TWT	HIIT	VIIT	OWT	TWT	HIIT	VIIT
All countries	46.93	53.07	14.09	38.98	44.34	55.66	13.27	42.38
Advanced countries	39.55	60.45	16.65	43.80	36.77	63.23	15.89	47.34
Newly Industrializing countries	78.08	21.92	3.20	18.72	66.47	33.53	5.83	27.70

Source: Comext Database. Note: OWT = one-way trade/inter-industry trade; TWT = two-way trade/intra-industry trade; HIIT = horizontal intra-industry trade; VIIT = vertical intra-industry trade.

Table 4: Two-digit industries included in analysis

Food products and beverages; textiles; wearing apparel, fur; leather products and footwear; wood and products of wood (furniture not included); pulp, paper and paper products; printing and publishing; chemicals and chem. products; rubber and plastics products; non-metallic mineral products; basic metals; fabricated metal products; machinery and equipment n.e.c.; office and computing machinery; electrical machinery n.e.c.; radio, TV and communication equipment; medical and precision instruments; motor vehicles; other transport equipment; furniture, manufacturing n.e.c. (20 industries)

Note: n.e.c .= not elsewhere classified

Table 5: German trading partners included in analysis (45 countries)

Advanced partner countries: Netherlands, France, Belgium, Luxemburg, UK, Austria, Italy, Norway, Switzerland, Sweden, Spain, USA, Denmark, Finland, Canada, Australia, Ireland, Portugal, Greece, Japan. (20 countries)

Newly industrializing countries: Russia, Poland, Czech Republic, Hungary, Romania, Lithuania, Estonia, Latvia, Slovenia, Slovakia, Bulgaria, Ukraine, Turkey, Brazil, Mexico, China, Thailand, India, South Korea, Indonesia, Taiwan, Singapore, Hong Kong, Egypt, South Africa. (25 countries)

Table 6: Regression results

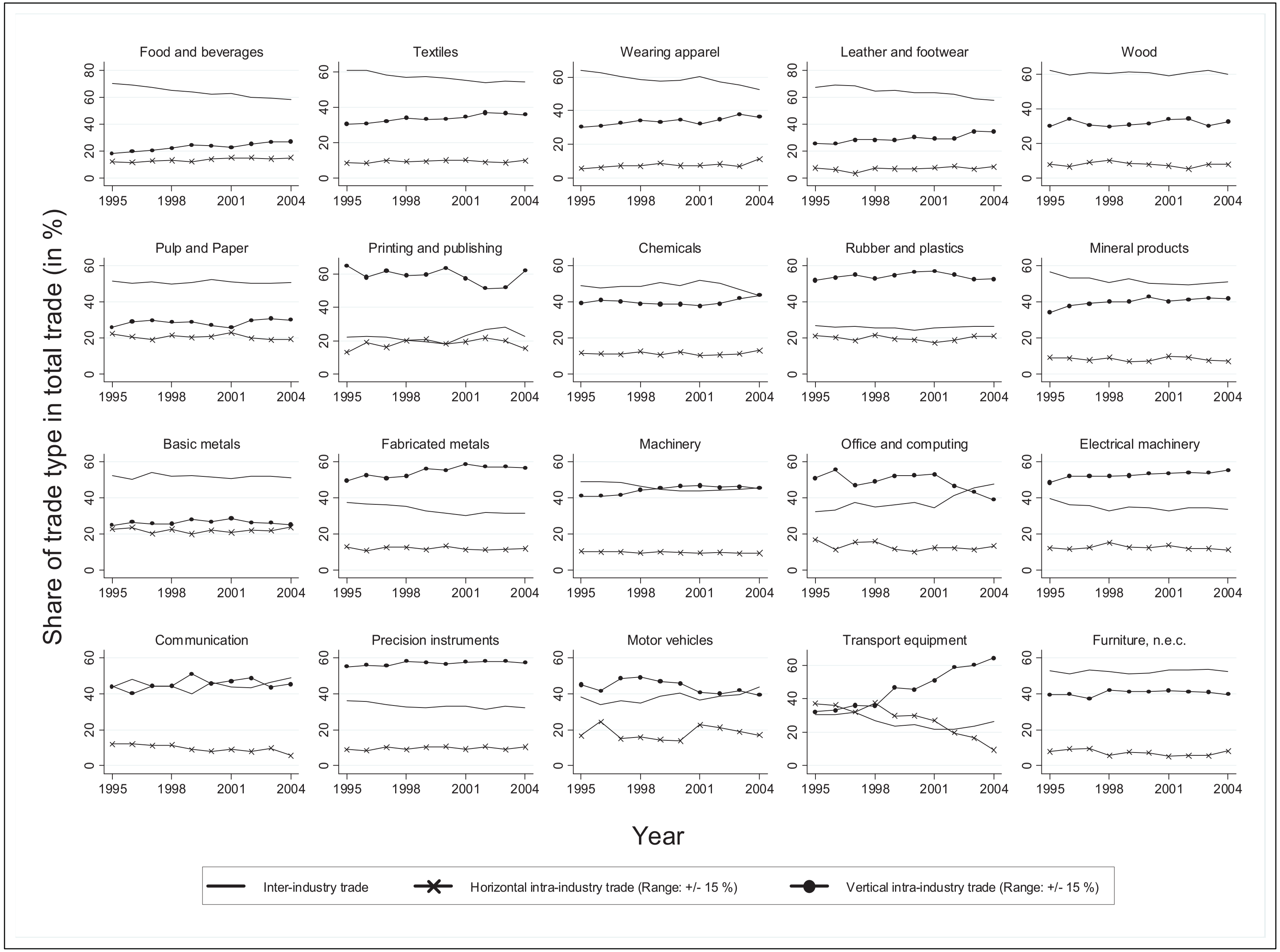
Dependent Variable: ΔWS_t^{LS}

	Range: 15%[1]				Range: 25%[2]			
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
$\Delta\ln(Y)_t$	6.016***	5.973***	5.098***	4.946***	5.793***	5.741***	5.249***	5.069***
$\Delta\ln(Y)_{t-1}$			1.567	1.438			1.369	1.039
$\Delta\ln(P)_t$	2.902	3.342	7.285	8.202	3.906	5.638	10.32**	11.05**
$\Delta\ln(P)_{t-1}$			- 1.915	- 2.800			- 1.740	- 2.251
$\Delta\ln(E)_t$	- 4.387**	- 3.740*	- 4.466	- 5.768*	- 5.382**	- 5.564**	- 5.933**	- 5.434*
$\Delta\ln(E)_{t-1}$			- 1.896	- 0.310			- 1.541	-1.464
$\Delta\ln(OUT)_t$	- 0.068	- 0.065	- 0.122	- 0.132	- 0.059	- 0.048	- 0.165**	- 0.137
$\Delta\ln(OUT)_{t-1}$			- 0.231	- 0.194			- 0.266	- 0.242
$\Delta\ln(VIIT)_t^{ALL}$	- 1.579**		- 1.611*		- 1.082**		- 0.677	
$\Delta\ln(VIIT)_{t-1}^{ALL}$			- 0.745				0.280	
$\Delta\ln(VIIT)_t^{Advanced}$		- 1.856**		- 1.825**		- 1.057**		-0.997**
$\Delta\ln(VIIT)_{t-1}^{Advanced}$				- 1.091				0.149
$\Delta\ln(VIIT)_t^{NewlyIndustrializing}$		0.335		-0.094		0.115		- 0.103
$\Delta\ln(VIIT)_{t-1}^{NewlyIndustrializing}$				0.42				0.009
Cons	- 0.574***	- 0.564***	- 0.495***	- 0.501***	- 0.578***	- 0.551***	- 0.459***	- 0.439***
N	180	180	160	160	180	180	160	160
R^2-Adj.	0.239	0.227	0.202	0.205	0.217	0.213	0.247	0.225
VIIT contribution	4 %	4.7 %	4.1 %	4.6%	2.3 %	2.2 %	0 %	2.1 %

Source: Author's calculations. Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. All standard errors are robust to heteroskedasticity. Dependent Variable is the annual change in production workers' share in total wage bill. The time period under observation is 1995 to 2004. [1] Range between export and import unit values used to distinguish between VIIT and HIIT is +/- 15% (Greenaway et al., 1994 and 1995, Fontagné et al. 1997). [2] Range between export and import unit values is +/- 25% (Greenaway et al., 1994 and 1995).

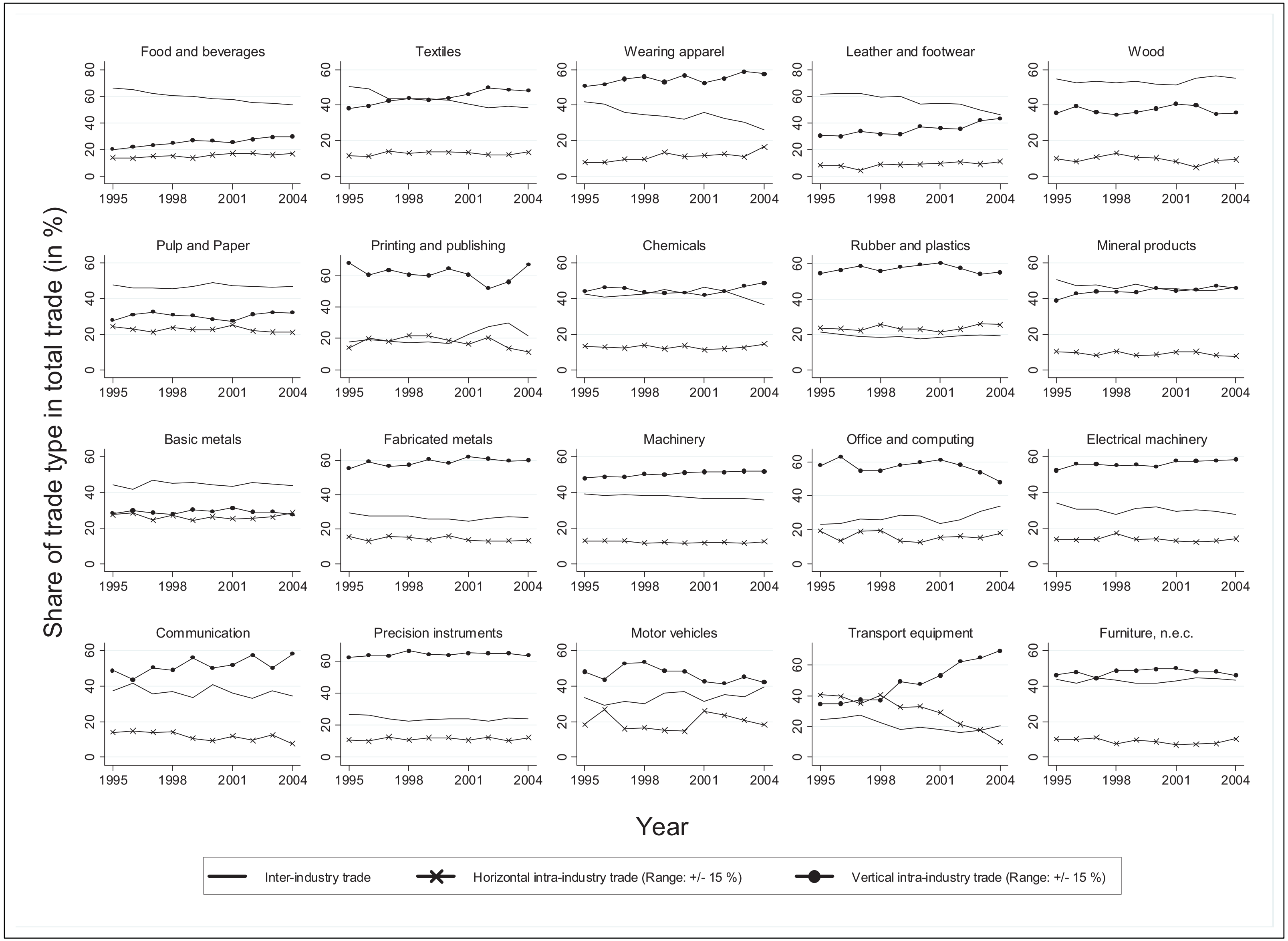
Figures

Figure 1: Trade patterns in German manufacturing industries between 1995 and 2004



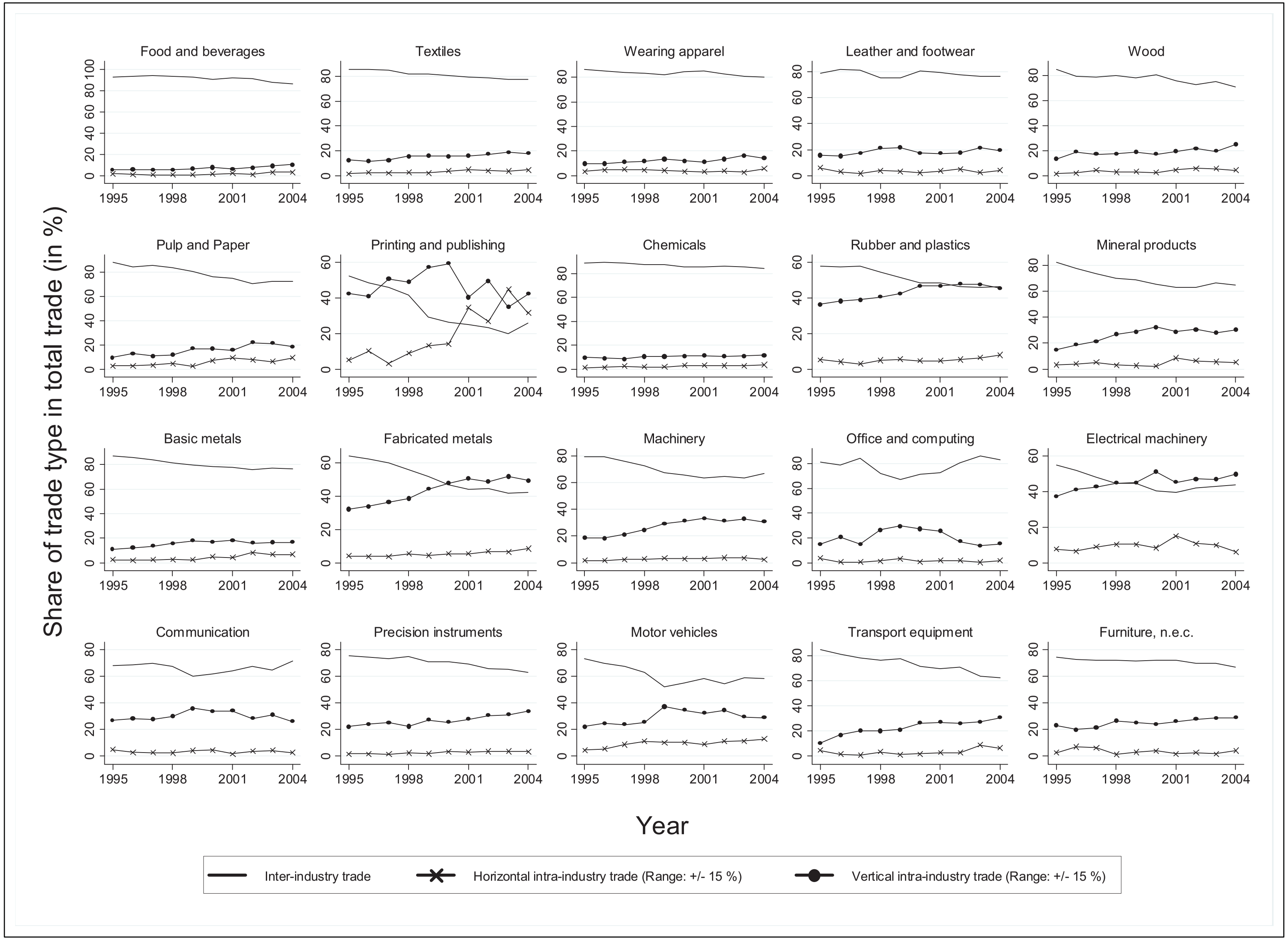
Source: Comext Database. Note: Calculation includes all 45 partner countries listed in the appendix.

Figure 2: Trade patterns with advanced countries in German manufacturing industries between 1995 and 2004



Source: Comext Database. Note: Calculation includes 20 advanced partner countries listed in the appendix.

Figure 3: Trade patterns with newly industrializing countries in German manufacturing industries between 1995 and 2004



Source: Comext Database. Note: Calculation includes 25 newly industrializing partner countries listed in the appendix.

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