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TECHNOLOGY, TRADE, AND INCOME DISTRIBUTION IN WEST GERMANY: A FACTOR-SHARE ANALYSIS, 1976-1994

Carsten Ochsen
University of Rostock

Heinz Welsch*
University of Oldenburg

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This paper examines the determinants of functional income distribution in West Germany. The approach is to estimate a complete system of factor share equations for low-skilled labor, high-skilled labor, capital, energy, and materials, taking account of biased technological progress and increasing trade-orientation. Technological progress is found to reduce the share of low-skilled labor and to raise the share of high-skilled labor. The effect of technology bias on the two labor shares is enhanced by substitution of intermediate inputs for low-skilled labor, which is almost absent in the case of high-skilled labor. Trade-induced changes in the composition of aggregate output tend to mitigate these effects, due to the relatively favorable export performance of low-skill intensive industries. The year-to-year variation in the low-skilled share can be attributed to input prices, biased technological progress, and trade-induced structural change in the proportion 19:77:4. For high-skilled labor and capital, the output composition effect of trade contributes about one percent. The results are robust across several specifications examined.

Key words: income shares, factor substitution, technological progress, trade
JEL classification codes: D33, F16, O30

I. Introduction

Functional income distribution in Germany, as in other industrialized countries, has undergone considerable changes over the last decades. From the mid-1970s to

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* Heinz Welsch (corresponding author): Department of Economics, University of Oldenburg, 26111 Oldenburg, Germany; phone +49-441-798-4112; fax +49-441-798-4116; e-mail welsch@uni-oldenburg.de. Carsten Ochsen: carsten.ochsen@wisofak.uni-rostock.de.
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the mid-1990s the share of high-skilled labor in West German value-added has been steadily increasing while the share of low-skilled labor decreased. Given the low initial value of the high-skilled share, its increase was too low to compensate the decreasing low-skilled share, leaving aggregate labor at a loss relative to capital. These changes in the shares of labor and capital in value-added were accompanied by a decrease of the share of value-added in gross output or, equivalently, an increase of the share of intermediates in gross output.

The most obvious reason for these changes in factor shares[1] consists of changes in the corresponding input prices. A straightforward example refers to one type of intermediate inputs, namely energy, whose share was high in the first half of the 1980s, when energy prices were high, and declined afterwards. In general, however, it is *not* obvious, how an input price influences the corresponding factor share. The basic impact of, say, an increase of negotiated wages is an increase of the labor share, but price-induced factor substitution may dilute or even reverse this effect. By the same token, price changes for one input may trigger changes of the shares of other factors, via substitution processes. The ultimate effect of input price changes is thus essentially a matter of substitution elasticities.

In addition to input prices, two major driving forces of factor shares have usually been proposed in the literature. The first is biased technological change. Biased technological change has especially been invoked in order to explain changes in the skill structure of labor (Berman, Bound and Machin 1998, Machin and van Reenen 1998), with obvious implications for the distribution of income among skill groups.

An alternative explanation rests on increasing trade orientation (‘globalization’). Globalization may influence factor shares in several ways.[2] First, increased international competition may be the trigger for input price changes considered above - an effect which has been discussed especially with respect to low-skilled workers in high-wage economies.[3] These linkages between trade and factor prices

[1] The term ‘factor share’ is more general than the term ‘income share’, as it encompasses inputs which do not belong to national income (value-added). It will be argued below that it is appropriate to consider all production inputs jointly in an analysis of functional distribution issues.

[2] The current thinking on income inequality and trade is discussed in Richardson (1995).

[3] Two theoretical frameworks have been used to analyze the links between changes in international trade and changes in the wage distribution. One focuses on the factor content of trade (see Freeman 1995), whereas the other emphasizes Stolper-Samuelson type links between factor prices and output prices which are set on world markets (see Leamer 1996).

have been examined mainly with respect to the United States, where wages are highly flexible. Europe and, especially, Germany are characterized by more centralized wage setting and relatively rigid wages. In these circumstances, the effect of increased trade on income distribution may work through unemployment of the corresponding factors (Krugman 1995), rather than through factor price changes. Second, globalization may induce a change in the composition of aggregate output, altering aggregate factor intensities and, hence, functional distribution. As a case in point, increased openness has been discussed as an explanation for 'deindustrialization' in industrialized economies (Saeger 1997). Third, there may be trade-induced substitution of intermediate inputs for capital or labor, a phenomenon which has been explained in terms of trade-induced specialization of production stages (Burda and Dluhosch 2002). Such processes of 'fragmentation' may not only involve domestic intermediates, but also imported intermediate products.

There are several related papers for West Germany. Fitzenberger (1999) examines trends in prices, total factor productivity, wages and employment. Using as a frame of reference a Heckscher-Ohlin-Samuelson (HOS) framework amended by non-neutral technological progress and rigid wages (Davis 1998), he finds that import competition jointly with wage rigidity has contributed to the increase in low-skilled unemployment in West Germany, 1970-1990. Estimating a system of wage and employment equations, Neven and Wyplosz (1999) also find some evidence for import competition hurting the labor market position of low-skilled workers. Since their data imply that import prices declined most for skill-intensive industries, this finding is not consistent with a simple HOS view, but implies that a more complicated process of restructuring must have taken place. Finally, estimating labor demand by skill groups, Kölling and Schank (2002) find that the West German skill structure is mainly determined by wages, whereas skill-biased technological change and international trade had only minor impacts.

In contrast to these studies which examine the relationship between trade, technology, and the skill structure, Falk and Koebel (2001) focus on the substitution pattern between capital, materials, and different types of labor in German manufacturing, but neglect the influences of technological progress and trade. They find, in particular, that a part of the shift away from unskilled labor is due to a substitution of materials for unskilled labor.

In contrast to the aforementioned papers, the present study aims at a comprehensive assessment of the impacts of technological progress, international trade, and substitution patterns among *all* inputs, not just different skill categories of labor. Our approach is to estimate a complete system of factor share equations for low-skilled labor, high-skilled labor, capital, energy, and materials in West Germany. Our approach of including the complete set of inputs allows not only to account for interactions among factor shares due to substitution processes. It also avoids specification bias, in the sense that omitting certain inputs may imply biased estimates of substitution possibilities even *within* the set of inputs actually included.[4]

The paper is organized as follows. Section II describes the model and methodological strategy as well as the data. Section III reports the estimation results and discusses their implications for the substitutability of the various inputs as well as the relative contributions of input prices, biased technological progress, and trade to the development of the factor shares. Section IV concludes.

II. Methodology and data

A. The model

Our point of departure is a cost function for aggregate gross output Q[5]:

$$C = F(p_1,..., p_n, Q, T, S), \qquad (1)$$

where p_1,..., p_n denote input prices, and T and S are shift parameters representing time (state of technology) and structure (output composition), respectively. The presence of S indicates that the cost of producing aggregate output Q may depend on the composition of Q in terms of different goods (production sectors).

The composition of Q may be influenced, in particular, by trade, due to the principle of comparative advantage. Since different goods have different input structures, trade may thus affect the demand for the various inputs and the corresponding income shares via changes in the *composition* of output. In addition, trade may affect input demand via changes in the *level* of output, as can be seen from the accounting identity $Q = D + EX - IM$ (where D stands for domestic demand and comprises intermediate demand, consumption, investment, and government expenditures).

A generic feature of any cost function is linear homogeneity in the input prices.

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[4] See Frondel and Schmidt (2002) for a discussion in a different context.

[5] Gross output includes GDP and intermediates.

Moreover, we assume linear homogeneity in Q. Choosing a translog specification for $F(.)$ and denoting unit costs by c, the unit cost function can be stated as

$$\ln c = \beta_0 + \sum_i \beta_i \ln p_i + 0.5 \sum_i \sum_j \beta_{ij} \ln p_i \ln p_j + \beta_T T + 0.5 \beta_{TT} T^2 + \sum_i \beta_{iT} \ln p_i T + \beta_S \ln S + 0.5 \beta_{SS} (\ln S)^2 + \sum_i \beta_{iS} \ln p_i \ln S + \beta_{TS} T \ln S. \tag{2}$$

Linear homogeneity in input prices requires the following regularity conditions:

$$\sum_i \beta_i = 1, \quad \sum_i \beta_{ij} = 0 \quad \text{for } j = 1, \ldots, n. \tag{3}$$

It is well known that for any proper unit cost function the share of factor i, s_i, is given by $\partial \ln c / \partial \ln p_i$. We thus obtain from eq. (2):

$$s_i = \beta_i + \sum_j \beta_{ij} \ln p_j + \beta_{iT} T + \beta_{iS} \ln S. \tag{4}$$

Assuming perfect competition, cost equals revenue, and the cost shares in eq. (4) correspond to revenue shares.

It is common to refer to the parameters β_i as distribution parameters and to β_{ij} as substitution parameters (Christensen, Jorgenson and Lau 1973). The distribution parameters measure the 'autonomous' revenue shares irrespective of input price changes, technological progress, and structural change. The substitution parameters measure how the autonomous shares change in response to input prices, via factor substitution. The substitution parameters are the basis for computing the elasticities of substitution between the various inputs (see Subsection D). They are assumed to be symmetric ($\beta_{ij} = \beta_{ji}$). The parameters β_{iT} measure the technology bias or non-neutral technological progress[6], and β_{iS} the

[6] The expressions technology bias and non-neutral technological progress will be used interchangeably. Biased or non-neutral technological progress will be called 'factor using' if it increases the respective factor share, and 'factor saving' if it reduces the share. It must be acknowledged, however, that a time trend may reflect more than just technical change but will also capture the impact of any omission that is correlated with time (omitted variables, false functional form, non-constant returns to scale etc.). More direct measures of the level of technology (computer equipment, R&D effort) have been suggested by Berman, Bound, and Machin (1998).

output composition bias.[7] Due to the presence of the technology bias and the output composition bias, the restrictions (3) are not sufficient to ensure adding-up of the share equations. For adding-up, the additional restrictions $\sum_i \beta_{iT} = \sum_i \beta_{iS} = 0$ are required.

The generic form of share equations as given in (4) is applied to a technology involving the following inputs: L = low-skilled labor, H = high-skilled labor, K = capital, E = energy, and M = materials. Since a major purpose of the paper is to identify the impact of trade on income distribution via changes in output composition, S is captured by economy-wide total (real) imports and exports relative to GDP (IM/GDP, EX/GDP). In several versions to be estimated we will include imports and exports jointly ('openness').

B. Estimation procedure

In order to estimate the equation system (4), we specify additive disturbances u_i. Since the factor shares sum to unity at each observation, the corresponding disturbance terms sum to zero, and the disturbance covariance matrix is singular. In these circumstances, it is common to delete one equation from the system of share equations. We delete the M share equation, impose the homogeneity restrictions (3), and estimate the following system of share equations:

$$s_i = \beta_i + \beta_{iL} \ln\left(\frac{p_L}{p_M}\right) + \beta_{iH} \ln\left(\frac{p_H}{p_M}\right) + \beta_{iK} \ln\left(\frac{p_K}{p_M}\right) + \beta_{iE} \ln\left(\frac{p_E}{p_M}\right) + \tag{5}$$

$$\beta_{iT} T + \beta_{iIM} \ln\left(\frac{IM}{GDP}\right) + \beta_{iEX} \ln\left(\frac{EX}{GDP}\right) + u_i ,$$

for $i = L, H, K, E$ with cross-equation symmetry imposed. The parameters which do not appear in (5) are recovered from the homogeneity and symmetry restrictions.

In order to ensure that the estimation results do not depend on which equation is deleted, we estimate the equation system (5) using the method of Iterated Three Stage Least Squares (see Berndt 1991 for a discussion in the present context). The

[7] With respect to the former, it should be noted that time is included in absolute, not in logarithmic form. This choice is made for ease of interpretation: β_{iT} measures the autonomous year-to-year change in s_i. We checked formulations in which time is included in logarithmic form and found that this modification did not affect our main conclusions.

instruments used are the lagged input quantities (in addition to the explanatory variables), where the lagged value of the first observation is obtained by solving backward a simple autoregressive model. This method also accounts for possible endogeneity of regressors.[8]

C. Decomposition procedure

We wish to attribute changes in factor shares to various driving forces, especially input prices, technological progress, and trade. Let $\hat{\beta}$ denote estimates of the β's. Then equation (4) can be written as follows:

$$\hat{s}_i = [\hat{\beta}_i] + [\hat{\beta}_{iL} \ln p_L] + [\hat{\beta}_{iH} \ln p_H] + [\hat{\beta}_{iK} \ln p_K] + [\hat{\beta}_{iE} \ln p_E] + \qquad (6)$$

$$[\hat{\beta}_{iM} \ln p_M] + [\hat{\beta}_{i,T} T] + [\hat{\beta}_{i,IM} \ln(IM / GDP)] + [\hat{\beta}_{i,EX} \ln(EX / GDP)].$$

Let the terms in square brackets be denoted by $\hat{s}_{i0}, \hat{s}_{i1}, ..., \hat{s}_{i8}$. These terms can be grouped as follows: The terms $\hat{s}_{i1}, ..., \hat{s}_{i5}$, which include the relative input prices and associated substitution parameters, represent the contribution of factor substitution to the variation in factor shares, whereas $\hat{s}_{i6}$ measures the contribution of non-neutral technological progress, and the terms $\hat{s}_{i7}$ and $\hat{s}_{i8}$ represent the effect of trade (via output composition changes).

A straightforward way of allocating changes in the factor shares to the various driving forces can be written as follows:

$$\frac{\Delta \hat{s}_i}{\hat{s}_i} = \sum_{j=1}^{8} \frac{\Delta \hat{s}_{ij}}{\hat{s}_{ij}} \frac{\hat{s}_{ij}}{\hat{s}_i}, \qquad (7)$$

where $\Delta \hat{s}_i / \hat{s}_i$ and $\Delta \hat{s}_{ij} / \hat{s}_{ij}$ denote relative changes over the time horizon, with $\hat{s}_i$ and $\hat{s}_{ij}$ indicating base year figures. This kind of decomposition refers to the longer term, that is to the factor shares in 1994 relative to 1976, without regard to short-term volatility. It is obvious that the terms on the right hand side of this formula may be of different signs, where the respective signs indicate whether one of the drivers has reduced or increased a factor share in the longer term.

In addition to this kind of analysis, it may be desirable to measure the

[8] Endogeneity of input prices may arise especially because of a response of wages to changes in factor shares, or due to trade and technological progress. Import and export shares may be influenced by input prices and by technological progress.

contributions of the factor substitution, technological progress, and trade effects to the variation in factor shares in such a way that short-term (year-to-year) fluctuations - which may smooth out in the longer term - are captured in a comprehensive way. This can be achieved by using a variance decomposition:[9]

$$\text{var}(\hat{s}_i) = \sum_{j=0}^{8} \text{var}(\hat{s}_{ij}) + 2\sum_{k<j} \text{cov}(\hat{s}_{ij}, \hat{s}_{ik}). \qquad (8)$$

The variance terms on the right hand side measure the contributions - in absolute terms - of various driving forces to the variation in factor shares. The non-negativity of variances allows to compute meaningful percentage contributions to the overall variation. The covariance terms represent interaction effects which cannot be attributed to any single driving forces.

Below we will apply both of these ways of assessing the determinants of changes in factor shares. Each of these methods focuses on different aspects of changes in cost shares.

D. Measuring substitutability

In order to measure the degree of substitutability between any two inputs we use the Morishima elasticity of substitution (MES). The MES measures the negative percentage change in the ratio of input *i* to input *j* when the price of input *i* alters.[10] It can be written as

$$MES_{ij} = -(\eta_{ii} - \eta_{ji}), \qquad (9)$$

where η_{ii} and η_{ji} denote the own price elasticity of input *i* and the cross price elasticity of input *j* with respect to the price of input *i*.

It has been forcefully argued by Blackorby and Russell (1989) that the MES is a natural generalization of the two-factor elasticity of substitution to the case of more than two inputs. Especially, the MES is a meaningful measure of the ease of substitution among any pair of inputs, whereas the usually employed Allen elasticity

[9] See any elementary statistics textbook.

[10] More precisely, the Morishima elasticity of substitution between input *i* and input *j* is defined as follows: $MES_{ij} = -\frac{\partial \ln(x_i / x_j)}{\partial \ln(p_i / p_j)}$ at p_j = constant.

of substitution (AES) may fail to indicate the ease of substitution. A natural property of the MES is asymmetry. Input *j* is a Morishima substitute (complement) for input *i* if $MES_{ij} > (<) 0$.

In the translog framework, the Morishima elasticities take the following form:

$$MES_{ij} = -[\frac{\beta_{ii}}{s_i} - \frac{\beta_{ji}}{s_j} - 1]. \qquad (10)$$

as can be computed from eq. (9), using the formulas for η_{ii} and η_{ji} given in Berndt (1991).

E. Data

Our data set consists of aggregate time series of the West German production sector, 1976-1994. Our choice to employ an aggregate rather than a sectoral framework of analysis is based on data availability: We wish to estimate a factor demand system in which labor is differentiated by skill category to test whether different skills display different substitutability/complementarity relationships with capital, materials and energy. Appropriate data by skill group are available only at an aggregate level.[11] The time period 1976-1994 is also dictated by data availability. After 1994, official statistics contain data only for unified Germany; no separate data for West Germany are provided any more. For the time before 1976 we have no data on the different skill-levels of labor.

Our data are taken from various sources. The basic data category are the factor shares in the base year, which are taken from the national accounts of the Federal Statistical Office (Statistisches Bundesamt 1994). The base year shares are updated by using rates of change of prices and quantities. Data on employed labor by skill category (low, high) are taken from the Education Accounts (Bildungsgesamtrechnung) as presented in Reinberg and Hummel (1999). The skill categories reflect levels of formal education. High-skilled labor comprises persons with a technical college or university degree, whereas low-skilled labor comprises all others. Since representative wages by formal education level are unavailable,

[11] There do exist studies which use sectoral data for differentiated labor (Fitzenberger 1999, Falk and Koebel 2001, Geishecker 2002), but they refer only to manufacturing. In this paper we are interested in general income distribution. Therefore, neglecting the non-manufacturing sectors (especially services) - for which no differentiated labor data are available - would be inappropriate.

they are proxied by wages for blue-collar and white-collar workers, taken from the Federal Statistical Office's online service (printed version is Fachserie 16: Löhne und Gehälter).[12] The required data on capital (prices and quantities) are taken from OECD (1996) and the data on energy from the annual reports of the Council of Economic Experts (Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung). Prices and quantities of materials are constructed from accounting relationships between the aforementioned variables (adding-up of factor shares) jointly with additional information from input-output accounting.

Our data base provides us with 76 independent observations (4 independent factor shares times 19 years). Our central estimating equations (see Section III.A) contain 28 parameters, of which only 22 are independent, due to 6 cross-equation symmetry constraints (see Subsection A). We thus estimate 22 parameters from 76 observations.

For reference below, Table 1 presents the factor shares and corresponding price indices for selected years. These data reveal, especially, the decline of the low-skilled share and the increase of the high-skilled share, as well as the fact that the low-skilled wage exhibited the strongest increase relative to the other inputs.

Table 1. Factor shares and price indices

	S_L	S_H	S_K	S_E	S_M
1976	0.249	0.076	0.123	0.050	0.503
1985	0.232	0.093	0.121	0.064	0.490
1994	0.208	0.101	0.128	0.042	0.521
	p_L	p_H	p_K	p_E	p_M
1976	1.000	1.000	1.000	1.000	1.000
1985	1.521	1.485	1.452	1.743	1.360
1994	2.114	2.049	1.942	1.569	1.748

[12] We deem these proxies to be appropriate because a comparison with selected micro-data on wages by skill suggests a fairly good agreement with respect to their dynamic behavior, see Abraham and Houseman (1995), Steiner and Wagner (1998).

III. Empirical results

A. Basic estimation results

We estimated several versions of the model presented in (5). The results are presented in Table 2.[13] Version A includes the price terms only. We find that 15 out of the 20 coefficients are significant at the 5 percent level or better. Augmenting this version by the non-neutral technological progress terms (version B) yields a positive but insignificant estimate of the progress coefficient in the capital equation, a significant positive estimate in the high-skill equation, and significant negative estimates of the progress coefficients in the low-skill and energy equations. Whereas the t-values of several coefficients get improved in the energy equation several of the t-values in other equations get reduced. By switching from version A to version B, the adjusted R-squared improves substantially in all equations except for the high-skill equation.

In version C (not shown) we add the trade variables to the previously included regressors. It turns out that both the import and the export variable are insignificant in all equations. In addition, technological progress becomes insignificant in the low-skill equation, and the t-values of the progress coefficients in the high-skill and energy equation get reduced (but remain significant). It can therefore be conjectured that the specification C may be plagued with considerable multicollinearity problems.

Multicollinearity may exist especially between trade (imports and exports) and technology, or between imports and exports. We first address the former possibility. In version D (not shown) technological progress is deleted in order to check whether this leads to significance of the trade variables. It turns out that this is not the case, except for $\beta_{M,IM}$ which becomes almost significant. In order to check whether the problems stem from multicollinearity *among* imports and exports, we include the *sum* of imports and exports (as a fraction of GDP) - being an overall measure of 'openness' - rather than both variables separately.

If openness (denoted by O) and technological progress are included *jointly* (version E) openness is insignificant in all equations. In version F, technological progress is deleted, i.e. only prices and openness are included. It is revealing that

[13] We also estimated versions which include dummy variables to account for possible structural breaks in the early 1990s in connection with the German unification. We found no evidence that the unification had an impact on West German factor shares.

in this case openness becomes significant in all equations except for the high-skill-equation. We are thus left with the conclusion that a serious multicollinearity problem exists not only between imports and exports, but also between imports and exports considered jointly (openness) and biased technological progress. Overall, as evidenced by versions B and F, biased technological progress and increasing openness both have an effect on most of the factor shares, but multicollinearity prevents these effects from being identified jointly, as attempted in version E. If technological progress is omitted, as in version F, openness takes over the part of technological progress, and the openness coefficients take on the signs of the progress coefficients.

Upon closer inspection of version E we find that the coefficients on openness are insignificantly negative in the capital and high-skill equations, and insignificantly positive in the low-skill and energy equations. There are other insignificant parameters as well. Especially, progress is insignificant in the capital equation. Moreover, several of the insignificant estimates with identical sign are of a similar magnitude, suggesting that they may in fact be equal.

Based on the latter consideration, we choose the strategy of imposing additional equality constraints on version E. More specifically, we impose the restrictions $\beta_{KO} = \beta_{HO}$, $\beta_{LO} = \beta_{EO}$, and $\beta_{KT} = \beta_{HT}$. This yields version G. The estimation results for this version are very satisfactory in that a substantial improvement (over version E) in t-values occurs.[14] Only the own-price coefficients in the capital equation and in the low- skill equation remain strongly insignificant. We fine-tune this version by dropping these two coefficients (version H). In this version, all coefficients of the complete system are significant at conventional confidence levels.[15]

Regression H is our preferred model.[16] It will be used especially to assess the contribution to factor share changes of factor substitution, technological change, and trade effects (see Subsection D). To check for robustness with respect to the constraints imposed we will complement these assessments by additional ones based on regressions E and G.

The most important conclusions to be drawn at this point are the following: The factor shares of capital and high-skilled labor as well as materials are subject

[14] The equality constraints are acceptable on the basis of Wald tests.

[15] Openness in the capital and high-skill equations is significant at the 7.10 percent level.

[16] We tested for overidentification using the J-statistic. As a result, the set of instruments is uncorrelated with the error terms, that is, the instruments are exogenous.

Table 2. Estimation results

Model	A	B	E	F	G	H
β_K	0.1183	0.1177	0.1180	0.1180	0.1179	0.1173
	(33.07)	(55.30)	(53.65)	(54.70)	(52.02)	(67.76)
β_L	0.2542	0.2541	0.2539	0.2546	0.2539	0.2547
	(54.27)	(105.39)	(106.53)	(96.72)	(101.05)	(145.79)
β_H	0.0746	0.0779	0.0779	0.0753	0.0780	0.0782
	(99.17)	(97.16)	(91.35)	(109.78)	(88.79)	(115.29)
β_E	0.0495	0.0502	0.0502	0.0496	0.0505	0.0505
	(44.99)	(90.40)	(87.90)	(79.90)	(87.50)	(90.22)
β_M	0.5035	0.5001	0.5000	0.5024	0.4998	0.4993
	(174.20)	(291.79)	(287.62)	(296.47)	(278.51)	(341.14)
β_{KK}	-0.0948	-0.0637	-0.0592	-0.0781	0.0141	0
	(-2.48)	(-1.12)	(-0.85)	(-1.79)	(0.46)	
β_{LL}	-0.3588	-0.1374	-0.0319	-0.3173	0.0189	0
	(-3.92)	(-1.76)	(-0.38)	(-3.45)	(0.49)	
β_{HH}	0.0611	0.0127	0.0779	0.0002	0.0843	0.0789
	(0.63)	(0.29)	(3.10)	(0.00)	(3.58)	(3.64)
β_{EE}	0.0485	0.0597	0.0603	0.0572	0.0613	0.0612
	(13.73)	(27.15)	(25.82)	(23.49)	(26.14)	(26.34)
β_{MM}	0.0263	-0.0391	-0.0260	0.0500	-0.0215	-0.0260
	(0.99)	(-1.49)	(-0.91)	(1.99)	(-1.26)	(-2.05)
β_{KL}	0.1051	0.0381	0.0122	0.0694	-0.0530	-0.0407
	(2.37)	(0.64)	(0.17)	(1.43)	(-2.20)	(-5.01)
β_{KH}	-0.0427	-0.0146	-0.0015	-0.0502	-0.0284	-0.0243
	(-3.60)	(-0.75)	(-0.06)	(-4.03)	(-2.84)	(-5.55)
β_{KE}	0.0221	-0.0154	-0.0170	-0.0069	-0.0227	-0.0222
	(2.36)	(-2.02)	(-1.98)	(-0.94)	(-2.95)	(-2.93)
β_{KM}	0.0103	0.0555	0.0655	0.0657	0.0900	0.0872
	(0.40)	(1.81)	(1.74)	(3.01)	(4.76)	(5.64)
β_{LH}	0.1170	-0.0044	-0.0745	0.1506	-0.0473	-0.0468
	(1.38)	(-0.11)	(-2.25)	(1.69)	(-2.21)	(-2.25)
β_{LE}	-0.0245	0.0255	0.0273	0.0175	0.0323	0.0321
	(-2.00)	(3.04)	(3.00)	(1.96)	(3.78)	(3.77)
β_{LM}	0.1613	0.0782	0.0670	0.0798	0.0492	0.0555
	(4.38)	(1.69)	(1.30)	(2.15)	(1.35)	(2.60)
β_{HE}	0.0083	0.0156	0.0170	0.0135	0.0191	0.0189
	(2.65)	(5.19)	(4.95)	(4.52)	(6.08)	(6.17)

Table 2. (Continued) Estimation results

Model	A	B	E	F	G	H
β_{HM}	-0.1436	-0.0093	-0.0189	-0.1142	-0.0277	-0.0267
	(-6.46)	(-0.51)	(-1.11)	(-3.51)	(-2.43)	(-4.11)
β_{EM}	-0.0544	-0.0854	-0.0876	-0.0814	-0.0899	-0.0900
	(-6.65)	(-14.09)	(-13.25)	(-14.11)	(-13.82)	(-13.86)
β_{KT}		0.0006	0.0009		0.0014	0.0013
		(1.21)	(0.64)		(15.33)	(17.15)
β_{LT}		-0.0013	-0.0022		-0.0024	-0.0023
		(-2.12)	(-1.53)		(-7.12)	(-11.88)
β_{HT}		0.0014	0.0016		0.0014	0.0013
		(7.21)	(3.10)		(15.33)	(17.15)
β_{ET}		-0.0005	-0.0007		-0.0009	-0.0009
		(-7.18)	(-2.73)		(-4.69)	(-4.99)
β_{MT}		-0.0001	0.0005		0.0006	0.0006
		(-0.29)	(0.51)		(1.09)	(1.51)
β_{KO}			-0.0079	0.0290	-0.0054	-0.0050
			(-0.19)	(2.09)	(-1.87)	(-1.84)
β_{LO}			0.0284	-0.0430	0.0145	0.0149
			(0.66)	(-2.52)	(2.00)	(2.15)
β_{HO}			-0.0067	0.0069	-0.0054	-0.0050
			(-0.42)	(1.08)	(-1.87)	(-1.84)
β_{EO}			0.0062	-0.0206	0.0145	0.0149
			(0.65)	(-6.95)	(2.00)	(2.15)
β_{MO}			-0.0200	0.0278	-0.0183	-0.0197
			(-0.71)	(2.60)	(-1.86)	(-2.11)
s_K $\bar{R}^2$	-0.5442	0.4115	0.3948	0.3736	0.2989	0.3576
s_L $\bar{R}^2$	0.5405	0.8834	0.8866	0.8473	0.8626	0.8715
s_H $\bar{R}^2$	0.9563	0.9418	0.9326	0.9734	0.9221	0.9233
s_E $\bar{R}^2$	0.8981	0.9730	0.9714	0.9643	0.9693	0.9692

Note: Figures in parenthesis are t-statistics, $\bar{R}^2$ is the adjusted coefficient of determination.

to factor using technological progress, whereas the shares of low-skilled labor and energy are driven by factor saving technological progress. In contrast to progress, openness biases factor shares to the disadvantage of capital and high-skilled labor as well as materials and to the advantage of low-skilled labor and energy.

These results are fairly robust qualitatively across the specifications E, G, and H.

Some of the results concerning the pattern of the openness bias are unexpected and warrant some discussion. This discussion is postponed until Subsection C because it involves the interaction between trade and factor substitution. Factor substitution will now be addressed.

B. Factor substitution

Table 3 reports the average Morishima elasticities of substitution between the various inputs. The table can be read row-wise and column-wise. The entries in row *i* indicate the possibilities of substituting input *i* by other inputs if the price of input *i* rises. The entries in column *j* indicate the possibilities of substituting input *j* for other inputs if the prices of those other inputs rise.

Table 3. Average Morishima elasticities of substitution

MES_{ij}	*L*	*H*	*K*	*E*	*M*
L	-	0.479	0.661	1.636	1.110
		(2.08)	(9.81)	(9.89)	(26.28)
H	-0.082		-0.081	0.496	0.069
	(-0.55)	-	(-0.40)	(2.01)	(0.30)
K	0.823	0.730		0.560	1.172
	(23.37)	(15.06)	-	(3.80)	(38.38)
E	-0.075	-0.004	-0.399		-0.392
	(-9.02)	(-0.36)	(-22.6)	-	(-12.1)
M	1.293	0.754	1.777	-0.733	
	(19.13)	(16.14)	(17.21)	(-7.25)	-

Note: Figures in parentheses are t-statistics.

Considering the first row, we find that low-skilled labor can be substituted by all other inputs, especially energy and materials. This is all the more important in explaining the declining income share of low-skilled labor because, over the period considered, the low-skilled wage grew by a factor of 1.34 relative to the energy price and by a factor of 1.21 relative to the price of materials (see Table 1). Since MES_{LE} is strongly above unity, the substitution of energy for low-skilled labor is strong enough to dominate the increase in the low-skilled wage and, hence, likely played a role in the decline of the low-skilled share.[17] The same applies to the substitution of materials for low-skilled labor, even though to a smaller extent.[18]

The situation is different for high-skilled labor (second row). High skilled labor cannot be substituted by any other input except energy[19], and the substitution elasticity vis-a-vis energy is below unity. Thus, even though the high-skilled wage grew by a factor of 1.31 relative to the energy price, substitution of energy for high-skilled labor is not pronounced enough to hurt the high-skill share.[20]

As evidenced in the third row, capital can be substituted by all other inputs, but only relative to materials is the substitution elasticity above unity. Since the user cost of capital grew by a factor of 1.11 relative to the price of materials, substitution of materials for capital took place and had an adverse effect on the capital share.

Since we are interested mainly in the distribution of income (value-added), not in factor shares in general, we will not discuss the fourth and the fifth rows in depth.[21] Turning to a column-wise analysis and considering the first column, we find that low-skilled labor could - technologically - substitute capital and materials, but not high-skilled labor and energy. However, the former possibilities are irrelevant because the low-skilled wage grew stronger than the prices of capital and materials. High-skilled labor (second column) is able to substitute - to some degree - all other

[17] The substitution of energy - especially electricity - for low-skilled labor involves, for instance, what is usually called ‘automatization’ of industrial processes.

[18] Falk and Koebel (2001) also find a substitution of intermediates for low-skilled labor. They speculate that this may indirectly reflect the impact of foreign competition in that semifinished goods produced by foreign labor are substituted for domestic unskilled labor. Their approach does not address the impact of trade directly.

[19] This results entails, especially, a confirmation of the ‘capital-skill complementarity’ hypothesis. The substitution of energy for high-skilled labor concerns, e.g., electronic data processing.

[20] It may be noted that the substitutability of high-skilled labor is noticeably higher towards the end of the time span than the average across time. However, even in 1994 the elasticity between high-skilled labor and energy is the only one which is significant.

[21] With respect to the fourth row, it may, however, be noted that we find all inputs to be complementary to energy, implying a positive own-price elasticity of energy. This could be due to shortcomings in the model specification, but we deem an explanation in terms of the composition of energy more appropriate: The period under consideration was characterized by a pronounced substitution of electricity for fuels (partly related to the process of ‘automatization’ mentioned in footnote 17). This means, there was a quality improvement in the energy aggregate to the effect that demand increased even if the price of the aggregate rose.

inputs except energy, whereas capital (third column) can substitute low-skilled labor and especially materials. The latter (technological) possibility is not relevant, given the evolution of the prices (see Table 1), but a substitution of capital for low-skilled labor did occur, even though it did not hurt the low-skilled share (due to the elasticity being below unity).

C. Discussion

We will now discuss our findings from Subsection A concerning the effects of increased openness on factor shares. Especially, the result that increased openness raises the share of low-skilled labor may be seen as being in contrast to previous findings (Fitzenberger 1999, Neven and Wyplosz 1999) and needs some clarification.

In order to understand this and related results, it is useful to differentiate the overall impact of trade on factor shares (or likewise factor demand) into (a) an effect relating to trade-induced changes in the composition of aggregate output (due to comparative advantage) and (b) an effect relating to the substitution of imported inputs for domestic inputs (due to input price differences). Our result relates only to issue (a), and additional evidence will be cited in support of this result. With respect to issue (b), this effect may in fact have worked to the disadvantage of low-skilled labor, but cannot be identified from our data. The overall effect may have been negative.[22]

With respect to issue (a) we are, unfortunately, unable to differentiate the effect of trade into separate effects of imports and exports. From a conceptual point of view, it can be said that a positive effect of increased openness on the shares of low-skilled labor and of energy would be consistent with low-skill intensive or energy intensive industries displaying relatively high export growth. Likewise, it would be consistent with these industries facing a low (or decreasing) degree of import competition. The converse applies in the case of the negative effects of openness on the shares of capital, high-skilled labor, and materials, i.e. the industries which are intensive with respect to these inputs should be characterized by relatively low export growth or increasing import competition, or both.

[22] Previous studies which found that trade has an adverse effect on low-skilled labor in West Germany (Fitzenberger 1999, Neven and Wyplosz 1999) were unable to differentiate between these partial effects because their scope was confined to different types of labor (and possibly capital). In the current study, both of these issues are addressed jointly, especially by including intermediate inputs (energy and materials).

From an empirical point of view, our finding concerning the negative impact of openness on the share of high-skilled labor is indeed consistent with the fact that West German import prices declined most for skill-intensive industries (Neven and Wyplosz 1999), implying increasing import competition for high-skilled labor. An observation consistent with increasing import competition for high-skilled labor is the fact that the share of high-technology products in German imports increased over the period 1980-1994 from 43.1 to 53.6 percent (Heitger, Schrader and Stehn 1999).

Given the (almost) steady increase of the German trade surplus[23], it would be inappropriate to focus exclusively on the import side. With respect to the relationship between factor intensities and export growth, we can refer to a companion paper (Welsch 2004) which presents the results of a regression exercise involving 26 manufacturing industries for which data on the skill structure of labor are available.[24] These regressions show that export growth has been higher in low-skill intensive industries than in high-skill intensive industries. In addition, export growth is positively related to intensity with respect to intermediate inputs (materials and energy) and capital.

The question arises how this phenomenon can be explained. In Subsection A we found evidence of low-skill-saving technological progress. This obviously contributed to reducing production costs in low-skill intensive industries. In addition, in Subsection B we found evidence of a substitution away from expensive low-skilled labor towards, especially, materials and energy. This reduced production costs further. As a consequence, the competitiveness of low-skill intensive industries rose and, via this channel, increased openness benefited low-skilled labor. This does not, however, imply that the *overall* effect of openness on low-skilled labor was favorable, since the intermediate inputs which were substituted for low-skilled labor include (an unknown fraction of) imported intermediates.[25]

In contrast to low-skilled labor, high-skilled labor is hardly prone to substitution

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[23] The *EX*/*GDP* ratio grew by a factor of 1.6 in 1976-1994, whereas *IM* / *GDP* grew by a factor of 1.4.

[24] These are the industries examined by Falk and Koebel (2001).

[25] See Falk and Koebel (2001) for a similar argument. Since the substitution of intermediate inputs for low-skilled labor may involve imported intermediates, low skilled labor may have been hurt by openness via this channel, but not via the impact of openness on the composition of aggregate output. This issue is discussed in the following Subsection.

by less expensive inputs (see Table 3), and technological progress is high-skill using rather than high-skill saving. Thus, even though the growth of high-skilled wages was slightly less than the growth of low-skilled wages (see Table 1), high-skill intensive industries may have lost in competitiveness, relative to low-skill intensive industries, and may thus have benefited less from increased access to world markets.

As concerns capital, its price rose less than the two types of wages. In addition, the Morishima elasticities of capital (Table 3) suggest that some substitution of materials for capital took place, raising the competitiveness of capital-intensive industries. This explains why these industries also had a relatively favorable export performance, as pointed out above. However, given that the price of capital increased relatively slowly, this effect was apparently not strong enough to have an impact on the income share of capital. In other words, the fact that capital intensive industries had a favorable export performance is not in contradiction with our result that increased openness affected the income share of capital negatively.

D. Weighting the roles of prices, technology, and trade

We now proceed by decomposing the variation in factor shares into their various components. The decomposition actually carried out slightly deviates from the decomposition described in (7) in so far as we cannot differentiate the effect of increasing trade orientation into an import-related and an export-related effect and must content ourselves with an overall openness effect.

We first consider the longer-term changes in factor intensities according to equation (7), as presented in Table 4.

We see that except for capital the estimated factor shares are not very sensitive to the models considered (letters E, G, and H refer to the models introduced in Table 2). Moreover, all models agree in that substitution reduced the share of both low-skilled and high-skilled labor as well as capital and raised the share of intermediates, while the share of energy was practically unaffected by substitution processes. With respect to all inputs the bulk of the factor share changes comes from technological progress. Trade-related changes in output composition played a minor role.

If we consider the short-term variation and its composition along the lines of equation (8), we obtain the results shown in Table 5. In this table, the interaction

Table 4. Decomposition of the change in factor share

	$\Delta\hat{s}_i / \hat{s}_i$				Substitution				Progress				Trade			
	E	G	H	Mean	E	G	H	Mean	E	G	H	Mean	E	G	H	Mean
$\hat{s}_L$	-0.19	-0.20	-0.20	-0.19	-0.08	-0.05	-0.06	-0.06	-0.16	-0.17	-0.16	-0.16	0.05	0.02	0.02	0.03
$\hat{s}_H$	0.28	0.28	0.27	0.28	-0.05	-0.01	-0.01	-0.02	0.37	0.31	0.31	0.33	-0.04	-0.03	-0.03	-0.03
$\hat{s}_K$	0.08	0.10	0.11	0.10	-0.02	-0.09	-0.08	-0.06	0.13	0.21	0.21	0.18	-0.03	-0.02	-0.02	-0.02
$\hat{s}_E$	-0.20	-0.21	-0.21	-0.21	-0.01	0.003	0.003	-0.00	-0.25	-0.33	-0.33	-0.30	0.05	0.12	0.12	0.10
$\hat{s}_M$	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.02	0.02	0.02	0.02	-0.02	-0.02	-0.02	-0.02

Table 5. Decomposition of the variation in factor shares (percent)

	Substitution				Progress				Trade			
	E	G	H	Mean	E	G	H	Mean	E	G	H	Mean
$\hat{s}_L$	23.3	18.3	15.9	19.2	70.1	79.9	82.2	77.4	6.7	1.8	2.0	3.5
$\hat{s}_H$	50.0	53.5	51.5	51.7	49.5	46.1	48.1	47.9	0.5	0.4	0.4	0.4
$\hat{s}_K$	42.5	35.8	27.8	35.4	54.8	63.6	71.6	63.3	2.7	0.6	0.6	1.3
$\hat{s}_E$	80.5	69.7	68.8	73.0	18.6	26.5	27.2	24.1	0.9	3.8	4.0	2.9
$\hat{s}_M$	91.4	90.3	89.7	90.5	4.1	6.2	6.4	5.5	4.5	3.5	4.0	4.0

effects shown in (8) are neglected and the substitution, progress, and trade effects are shown as percentages of their sum.[26]

Again, the three models do not differ fundamentally in the role they attribute to the various driving forces. We will focus on the mean across the various models.

The probably most outstanding result is that trade-induced structural change generally plays a minor role, which, however, tends to be larger for the intermediate inputs than for the primary inputs. Among the primary inputs, low-skilled labor is more affected by trade than are high-skilled labor and capital. The dominating influence on the shares of the intermediate inputs comes from substitution, whereas technology bias (progress) is of lesser importance. The converse is true for low-skilled labor and capital, whereas the contributions of substitution and progress to the variation of the high-skill share are almost equal.

The result that trade-induced structural change plays only a minor role for primary factor shares is consistent with findings that even in the United States changes in the industrial structure - irrespective of their cause (trade or other) - account only for a small fraction (16 percent) of changes in the structure of labor demand (Murphy and Welch 1993). On the other hand, a relatively large role played by technology bias is necessary for explaining rising skill-intensity in the face of rising skill-prices (see Gottschalk and Smeeding 1997).

With respect to the substitution component, a few more specific comments may be instructive. The contribution of this component is relatively large in the case of high-skilled labor and smaller in the cases of low-skilled labor and capital. One reason for the small contributions of substitution in the cases of low-skilled

[26] More specifically, *substitution* refers to $\mathrm{var}(\hat{s}_1)+\mathrm{var}(\hat{s}_2)+\mathrm{var}(\hat{s}_3)+\mathrm{var}(\hat{s}_4)+\mathrm{var}(\hat{s}_5)$ in the notation of Section II.C.

labor and capital is that the own-price effects are very low in the case of these two inputs, i.e. the effects on the respective factor shares of changes in the two corresponding prices are just offset by induced quantity changes in the opposite direction. The most important price-related impact on the low-skill share comes from the price of energy, whereas the impact of the materials price on the low-skilled share are much smaller. For capital, the most important price-related driver is the price of low-skilled labor, i.e. the increase in the low-skilled wage led to a substitution of capital for low-skilled labor, resulting in an increase of the capital share. Similarly, the share of high-skilled labor also benefited from a substitution of high-skilled labor for low-skilled labor, but the dominating price-related influence on the high-skill share is the change (increase) in the high-skill wage (own-price effect), which is far from being compensated by induced quantity changes, due to the low degree of substitutability of high-skilled labor.[27]

An open question is, to what extent the substitution of intermediates for low-skilled labor comprises imported intermediates. As mentioned above, the impact of the energy price on the low-skilled share is stronger than the impact of the materials price. In fact, given our estimates of the degrees of substitutability, the most important intermediate substitute for low-skilled labor is energy. Moreover, it is likely that low-skilled labor was mainly substituted by electricity (automatization of production processes), rather than by fuels. This view is also consistent with the result that the capital share benefited from the increase in the low-skilled wage: automatization mainly encompasses the substitution of capital and electricity for low-skilled labor.[28] Since electricity is basically non-traded (especially over the period considered), we are thus led to the conjecture that at least one type of the substitution of intermediate inputs for low-skilled labor was a purely domestic phenomenon.

This reasoning is -admittedly- somewhat speculative. More precise statements on the role of trade in the substitution of intermediates for low-skilled labor are impossible to derive from our analysis.[29]

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[27] With respect to the intermediate inputs, the most important price-related driver of factor shares is the energy price. Given the low degree of substitutability of energy (see Table 3), energy price changes have a strong impact on the energy share. In addition, given the complementarity relationship between materials and energy, energy price changes also have a strong impact on the share of materials.

[28] Recall from Table 3 that capital is a Morishima complement to energy (i.e. $MES_{EK} < 0$), which applies especially to electricity.

[29] Note that even though the fraction of imported intermediates in total intermediates is

IV. Conclusions

This paper has examined the determinants of functional income distribution in West Germany over the period 1976-1994. Our approach was to estimate a complete system of factor share equations for low-skilled labor, high-skilled labor, capital, energy, and materials, taking account of biased technological progress and increasing trade-orientation.

Our basic conclusions with respect to the roles of trade and technology are that the shares of capital and high-skilled labor benefit from biased technological progress, whereas the share of low-skilled labor is adversely affected by technological progress. The effect of technology bias on the two labor shares is enhanced by substitution of intermediate inputs for low-skilled labor, which is almost absent in the case of high-skilled labor. To the extent that this substitution involves imported intermediates, increased openness hurts low-skilled labor. Trade-induced changes in the composition of aggregate output tend to mitigate these effects, due to the relatively favorable export performance of low-skill intensive industries. The latter, in turn, is explicable by non-neutral technological progress and the increasing use of intermediates enhancing the competitiveness of low-skill intensive industries.

From a methodological point of view, our inclusion of the complete set of inputs proved to be rewarding as it allowed to separate the effect of substitution processes from trade-induced structural change. Since the latter influence turned out to have a positive impact on the income share of low-skilled labor, trade seems to have hurt low-skilled labor mainly via the substitution of imported intermediates for low-skilled labor. The extent to which this was the case is difficult to quantify. However, the overall contribution of trade to the year-to-year-variation in the factor shares of the primary inputs is small and vastly dominated by the contribution of biased technological progress.

References

Abraham, Katharine G., and Susan N. Houseman (1995), “Earnings inequality in Germany”, in R. B. Freeman and L. Katz, eds., *Differences and Changes in Wage Structures*, Chicago, University of Chicago Press.

known, we are unable to identify the amount of imported intermediates which serve as substitutes for low-skilled labor (or any other domestic input).

Berman, Eli, John Bound, and Stephen Machin (1998), "Implications of skill-biased technological change", *Quarterly Journal of Economics* **113**: 1245-1279.

Berndt, Ernst R. (1991), *The Practice of Econometrics: Classic and Contemporary*, Reading, MA, Addison-Wesley.

Blackorby, Charles, and Robert R. Russell (1989), "Will the real elasticity of substitution please stand up? A comparison of the Allen/Uzawa and Morishima elasticities", *American Economic Review* **79**: 882-888.

Burda, Michael C., and Barbara Dluhosch (2002), "Cost competition, fragmentation and globalization", *Review of International Economics* **10**: 424-441.

Christensen, Laurits R., Dale W. Jorgenson, and Lawrence J. Lau (1973), "Transcendental logarithmic production frontiers", *Review of Economics and Statistics* **55**: 28-45.

Davis, Donald Ray (1998), "Technology, unemployment, and relative wages in a global economy", *European Economic Review* **42**: 1613-1633.

Falk, Martin, and Bertrand Koebel (2001), "A dynamic heterogeneous labour demand model for German manufacturing", *Applied Economics* **33**: 339-348.

Fitzenberger, Bernd (1999), "International trade and the skill structure of wages and employment in West Germany", *Jahrbücher für Nationalökonomie und Statistik* **219**: 67-89.

Freeman, Richard B. (1995), "Are your wages set in Beijing?", *Journal of Economic Perspectives* **9**: 15-32.

Frondel, Manuel, and Christoph M. Schmidt (2002), "The capital-energy controversy: An artifact of cost shares?", *The Energy Journal* **23**: 53-79.

Geishecker, Ingo (2002), "Outsourcing and the demand for low-skilled labour in German manufacturing: New evidence", Discussion Paper 313, DIW.

Gottschalk, Peter, and Timothy Michael Smeeding (1997), "Cross-national comparisons of earnings and income inequality", *Journal of Economic Literature* **35**: 633-687.

Heitger, Bernhard, Klaus Schrader, and Jürgen Stehn (1999), *Handel, Technologie und Beschäftigung*, Tübingen, Mohr Siebeck.

Kölling, Arnd, and Thorsten Schank (2002), "Skill-biased technological change, international trade and the wage structure", mimeo, Institute for Employment Research, Nuremberg.

Krugman, Paul (1995), "Growing world trade: Causes and consequences", *Brookings Papers on Economic Activity* issue 1: 327-362.

Leamer, Edward E. (1996), "Wage inequality from international competition and technological change: Theory and country experience", *American Economic Review* **86**: 309-314.

Machin, Stephen, and John van Reenen (1998), "Technology and changes in skill structure: Evidence from seven OECD countries", *Quarterly Journal of Economics* **113**: 1215-1244.

Murphy, Kevin M., and Finis R. Welch (1993), "Industrial change and the rising importance of skill", in S. Danziger and P. Gottschalk, eds., *Uneven Tides: Rising Inequality in America*, New York, Russell Sage Foundation.

Neven, Damien, and Charles Wyplosz (1999), "Relative prices, trade, and restructuring in European industry", in M. F. Dewatripont, ed., *Trade and Jobs in Europe: Much Ado about Nothing?*, Oxford, Oxford University Press.

OECD (1996), *Flows and Stocks of Fixed Capital*, Paris.

Reinberg, Alexander, and Markus Hummel (1999), "Bildung und beschäftigung im vereinten Deutschland", *Beiträge zur Arbeitsmarkt- und Berufsforschung* no. 226, Nuremberg.

Richardson, John David (1995), "Income inequality and trade: How to think, what to conclude", *Journal of Economic Perspectives* **9**: 33-56.

Saeger, Steven Schaal (1997), "Globalization and deindustrialization: Myth and reality in the OECD", *Weltwirtschaftliches Archiv* **133**: 549-608.

Statistisches Bundesamt (1994), *Volkswirtschaftliche Gesamtrechnungen*, Fachserie 18, Reihe 2, Stuttgart.

Steiner, Viktor, and Karsten Wagner (1998), "Relative earnings and the demand for unskilled labor in West German manufacturing", in S. W. Black, ed., *Globalization, Technological Change, and Labor Markets*, Dordrecht, Kluwer Academic Publishers.

Welsch, Heinz (2004), "Skill intensity and export growth in West German manufacturing", *Applied Economics Letters* **11**: 513-515.