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Discussion Paper No. 93

Technical Change, Economies of Scale, and Factor Augmentation

Impacts on Relative Differences in Productivity and Price Competitiveness between U.S. and German Industries

by
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Summary

Our analysis of relative catching-up or falling behind processes in U.S. and German industries outlines major long- and short-term trends which emerged during the two and a half decades from 1960 to 1985. We distinguish 26 different industries which add up to the national aggregates of the economies.

We apply the bilateral factor demand system which was introduced by Jorgenson, Nishimizu (1978). It is generalized to include non-constant returns to scale. A translog cost function model of this type was first applied by Gollop, Roberts (1981) for a single industry. Our model is used to test hypothesis concerning permanent differences in the cost structure of particular industries of both countries, the form of neutral or of nonneutral technical change, differences or similarities in the rates of technological progress of both countries, and the question if there is a significant acceleration or deceleration of industrial TFP growth rates. Furthermore we test if there is a possible impact of non-constant returns to scale, and last but not least the relative catch-up or falling behind of cost efficiency levels for industries in both countries which contribute to international price competitiveness.

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Introduction

The notion of increasing returns to scale has always attracted the attention of economists. The work of Young (1928) started an early debate which, to my mind, is still unsettled as current research on endogenous growth theories indicates (cf. e.g. Romer, 1983, 1994; Helpman; Krugman, 1985; Grossman; Helpman, 1994; Solow, 1994). It significantly influenced the work of other outstanding economists of his time like Kaldor and the notion triggered the debate on imperfect competition as well with the contributions of Sraffa, Chamberlain and Robinson. Sources of increasing returns to scale are, according to Youngs view, the division of labor, specialization, advances in technology, augmentation of human capital (schooling, education, learning by doing, acquisition of knowledge, spillover of knowledge), ideas and knowledge as economic entities, institutions as economic entities, economic organization, restoration of economic equilibrium.[2]

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[1] I acknowledge the financial support of the German Marshall Fund of the United States. Without this support this research could not have been carried out. I am grateful to Professor Dale W. Jorgenson and Barbara Fraumeni for supplementing the US data and supporting the project by giving their helpful comments.

[2] Cf. for this summary Th. W. Schultz (1993), p.8.

The paper presented here is just an attempt to contribute to the debate as to whether increasing returns are empirically fact or artefact, and - if it is fact - to what extent one can identify its sources. Contrary to much empirical work on endogenous growth theory which focuses on the aggregate analysis, this discussion takes the stand that it is the structural composition of a national economy which matters. Therefore it studies the topic of returns to scale on an industry level. However, it is limited to a two-digit level of disaggregation by industries, but it tries to investigate the notion across the whole economy for two of the currently leading economies, the U.S. and Germany.

Theoretical Framework

The model applied here is based on the economic theory of production. Under the assumption of cost minimizing behavior, it follows from duality theory that production technology can be represented by its dual minimum cost function if certain regularity conditions are maintained.[3]

Traditionally (cf. e.g. Solow, 1956) it is assumed that technology will not differ between countries so that the parameters of technology of one country are the same for the other. Recently, Pack (1994, p. 66) in a summary on current empirical evidence on endogenous growth theories made the remark that "regardless of whether one is using a neoclassical or endogenous approach, it thus seems necessary to examine one country at a time, insofar as there is no identical international production function along which changes in capital exert their effect." Jorgenson and Nishimizu (1978) have already in their approach taken this into account by introducing country specific-parameters in production or a respective cost function to account for these differences and so as to be able to test if data support or reject the assumption of the equality of technology between countries.

The empirical testing of this hypothesis by a number of authors for a number of countries (the U.S., Japan and Germany) at an industry level showed that statistically significant differences between technologies of these countries could be observed at a two-digit industry level, therefore lending support to the hypothesis that the capability of countries to apply technology efficiently differs. However, the reasons for the observed differences might be attributed to a number of different sources like environmental factors (climate, topography),

[3] Note, however, that for the translog function used later on the property of self-duality is not generally valid except in the case of the Cobb-Douglas function which is included as a special case. A translog production function and a translog minimal cost function do not represent the same technology if the parameters of its quadratic terms are not all equal to zero.

infrastructure, institutional regulations, differences in the quality of input factors, differences in factor prices, differences in the composition of the industries or they might be caused to some extent by differences in definitions and measurement which remain unsolved. To identify the possible shortcomings of most currently available studies one would have to be able to disaggregate even further and study differences at a plant level for homogenous industries in different countries.[4]

In this study we assume that an industry level minimum cost function exists and that differences between each countries industry can be properly measured by country-specific parameters. A general bilateral cost function for two countries taking three input factors into account is then given for an industry s by:

$$C(Q^s) = G^s(p_K^s, p_L^s, p_M^s, Q^s, T, D_{US}) \qquad (1)$$

where production cost (C^s) is a function of the factor prices of capital (p_K^s), labor (p_L^s), and intermediate inputs (p_{Ms}), the level of output (Q^s), time (T), and a dummy variable (D_{US}). This latter variable is set equal to one for the U.S. and zero for Germany. Furthermore, we assume that factor markets are competitive. The current formulation of the cost function, however, avoids the assumption of constant returns to scale for an industry. A similar approach can be found in Nakamura (1992).

The derivative of the logarithm of the cost function (1) with respect to time gives us a decomposition of the rate of change of total costs into its source components:

$$\frac{d \ln C^s}{d T} = \left[\sum_{i \in \Psi} \frac{\partial \ln C^s}{\partial z_i^s} \cdot \frac{d \ln z_i^s}{d T} \right] + \frac{\partial \ln C^s}{\partial \ln Q^s} \cdot \frac{d \ln Q^s}{d T} + \frac{\partial \ln C^s}{\partial T}$$

$$with \quad i \in \Psi^s \equiv \{ K^s, L^s, M^s \} \qquad (2)$$

$$\wedge \quad z_i^s \in \{ \ln p_K^s, \ln p_L^s, \ln p_M^s \}$$

Therefore, the rate of change in total costs can be expressed as the cost elasticity weighted average of the changes in factor prices, plus the scale weighted rate of change in output, plus the rate of cost diminuition due to technical change.

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4 For such an approach and its problems, in generating the necessary data, cf. e.g. Mairesse, Hall (1993).

Similarly, the derivation of the logarithmic cost function with respect to the country dummy variable gives us a decomposition of the differences in the cost efficiency levels.

$$\frac{d \ln C^s}{d D_{US}} = \left[\sum_{i \in \Psi} \frac{\partial \ln C^s}{\partial z_i^s} \cdot \frac{d \ln z_i^s}{d D_{US}} \right] + \frac{\partial \ln C^s}{\partial \ln Q^s} \cdot \frac{d \ln Q^s}{d D_{US}} + \frac{\partial \ln C^s}{\partial D_{US}} \tag{3}$$

$$\text{with} \quad i \in \Psi^s \equiv \{ K^s, L^s, M^s \}$$

$$\wedge \quad z_i^s \in \{ \ln p_K^s, \ln p_L^s, \ln p_M^s \}$$

The difference in cost efficiency levels between the two countries is generated by the sum the of the cost el sticity weighted average of differences in factor prices, plus the scale weighted differences in outputs, plus the differences in the rate of technological progress.

In this study the general bilateral cost function defined in (1) is approximated by a second order approximation in its logarithms. This form is known in the literature as the translog cost function (cf. Christensen; Cummings; Jorgenson, 1971). It was first introduced by Jorgenson and Nishimizu (1978) in the more restrictive form that constant returns always prevail.[5]

$$\ln C(Q^s) = \sum_{i \in \Phi^s} \tilde{\alpha}_i^s \cdot z_i^s + \frac{1}{2} \sum_{i \in \Phi^s} \sum_{j \in \Phi^s} \tilde{\beta}_{ij}^s \cdot z_i^s \cdot z_j^s \tag{4}$$

$$\text{with} \quad i,j \in \Phi^s \equiv \{ K^s, L^s, M^s, Q^s, T, D_{US} \}$$

$$\wedge \quad z_i^s \in \{ \ln p_K^s, \ln p_L^s, \ln p_M^s, \ln Q^s, T, D_{US} \}$$

[5] The bilateral cost function under the restriction of constant returns to scale was used in a couple of studies afterwards. see for example K. Conrad; D. W. Jorgenson (1985); D. W. Jorgenson; M. Kuroda; M. Nishimizu (1987); K. Conrad (1988, 1989); D. W. Jorgenson; H. Sakuramoto; K. Yoshioka; M. Kuroda (1990) and G. Erber (1993).

Since the bilateral translog function is symmetric in all variables, the logarithmic partial derivatives with respect to factor prices, output, time and the country dummy variable are given by

$$\frac{\partial \ln C(Q^s)}{\partial z_i^s} = \alpha_i^s + \sum_{j \in \Phi^s} \beta_{ij}^s \cdot z_j^s \qquad (5)$$

$$with \quad i,j \in \Phi^s$$

Applying Shephard's lemma with respect to each input price, one obtains

$$\frac{\partial \ln C(Q^s)}{\partial \ln p_i^s} = w_i^s = \alpha_i^s + \sum_{j \in \Phi^s} \beta_{ij}^s \cdot z_j^s \qquad (6)$$

$$with \quad i \in \Psi^s \quad \wedge \quad j \in \Phi^s$$

Therefore, the elasticity of cost with respect to factor prices equals the corresponding cost share (w_i^s) of the total costs.

The elasticity of cost with respect to output can be interpreted as a measure of static scale economies.

$$\frac{\partial \ln C^s}{\partial \ln Q^s} = w_Q^s = \alpha_Q^s + \sum_{j \in \Phi} \beta_{Qj}^s \cdot z_j^s \qquad (7)$$

$$with \quad j \in \Phi^s$$

If w_Q^s equals unity, cost responds to changes in the output proportionally. This is the usual condition for constant returns to scale. If w_Q^s is less (greater) than unity, total costs increase less (more) than proportionally with increasing output, implying increasing (decreasing) returns to scale.

The rate of cost diminuition is defined by the partial elasticity of cost with respect to time.

$$\frac{\partial \ln C^s}{\partial T} = - g_T^s = \alpha_T^s + \sum_{j \in \Phi^s} \beta_{Tj}^s \cdot z_j^s \tag{8}$$

It is equal to the negative value of the rate of technological progress. Under the assumption of constant returns to scale it would be equal to the negative rate of change of total factor productivity (TFP) growth. If, however, increasing or decreasing economies of scale at an industry level exist, the standard Törnqvist index of TFP growth will be biased.[6]

The difference in cost efficiency levels is determined by the partial elasticity of cost with respect to the country dummy.

$$\frac{\partial \ln C^s}{\partial D_{US}} = - w_{US,G}^s = \alpha_D^s + \sum_{j \in \Phi^s} \beta_{Dj}^s \cdot z_j^s \tag{9}$$

As long as constant return to scale prevail, this could be measured by the standard Törnqvist index used by Jorgenson; Nishimizu (1978) and others. Under non-constant returns the standard measure will be biased as well.

Note that in the bilateral translog cost function model the rate of technological change and the differences in cost efficiency levels are partially endogenized by the development of relative factor prices and the levels of output demand. Furthermore, the model allows for time variable rates of technological change which are different in both countries and a time variable development in differences in the cost efficiency level of both countries. It also includes the possibility that technological change is factor augmenting. If relative factor prices in both countries develop differently, the model also allows for differences in the factor augmentation process in both countries. Since these differences in relative factor prices and output levels are given exogenously, it fails, however, to explain why these differences emerge. To estimate the parameters of the bilateral cost function we will use the bilateral factor demand system given by the equations (6) to (9). To be able to estimate this, we have to rewrite it so that on the left hand side we could use the biased measures of the rate of cost diminuition and the differences in the cost efficiency levels which one obtains from the standard Törnqvist indices. To see how this can be accomplished we will rearrange the terms of equation (2) and (3) so that the traditional measures are on the left and the remaining terms on the right hand side. We

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6 cf. e.g. Luke Chan; Mountain (1983).

substitute also the partial cost elasticities by their respective expression for the cost shares, static scale elasticity, etc.

For equation (2) we obtain

$$\frac{d \ln C^s}{d T} - \left\{ \sum_{i \in \Phi} w_i^s \cdot \frac{d \ln z_i^s}{d T} \right\} = w_Q^s \cdot \frac{d \ln Q^s}{d T} - g_T^s \tag{10}$$

and equation (3) becomes

$$\frac{d \ln C^s}{d D_{US}} - \left\{ \sum_{i \in \Phi} \bar{w}_i^s \cdot \frac{d \ln z_i^s}{d D_{US}} \right\} = w_Q^s \cdot \frac{d \ln Q^s}{d D_{US}} - w_{US,G}^s \tag{11}$$

To be able to estimate the model with annual data it has to be transformed into a discrete form. Instead of using Divisia indices for our calculation, we are approximating them by the corresponding Törnqvist indices, which are exact if production technology has the form of a translog function (see Diewert, 1976). The differentials are approximated accordingly by their first logarithmic differences. We thus obtain

$$g_{TFP,t}^s = w_{Q,t}^s \cdot \left(\ln Q_t^s - \ln Q_{t-1}^s \right) - g_{T,t}^s \tag{12}$$

and

$$\tilde{w}_{US,G;t}^s = w_{Q,t}^s \cdot \left(\ln Q_{US,t}^s - \ln Q_{G,t}^s \right) - w_{US,G;t}^s \tag{13}$$

The equations (12) and (13) together with the equation (6) form a factor demand system equivalent to that of equations (6) to (9) before. The difference is that now all necessary variables can be calculated.[7]

Substituting the parametric expressions, the factor demand system now becomes

$$w_{i,t}^{s} = \alpha_i^{s} + \sum_{j\in\Phi} \beta_{ij}^{s} \cdot z_{j,t}^{s}$$

$$g_{TFP,t}^{s} = \left(\alpha_Q^{s} + \sum_{j\in\Phi} \beta_{Qj}^{s} \cdot z_{j,t}^{s} \right) \cdot \left(\ln Q_t^{s} - \ln Q_{t-1}^{s} \right) + \alpha_T^{s} + \sum_{j\in\Phi} \beta_{Tj}^{s} \cdot z_{j,t}^{s} \tag{14}$$

$$\tilde{w}_{US,G,t}^{s} = \left(\alpha_Q^{s} + \sum_{j\in\Phi} \beta_{Qj}^{s} \cdot z_{j,t}^{s} \right) \cdot \left(\ln Q_{US,t}^{s} - \ln Q_{G,t}^{s} \right) + \alpha_D^{s} + \sum_{i\in\Phi} \beta_{Dj}^{s} \cdot z_{j,t}^{s} \tag{15}$$

To satisfy the adding-up condition (16), one of the cost share equations given by (6) has to be ommitted in the estimation. We decided to use the capital and intermediate input cost share equations and discard the labor cost share equation.

$$\sum_{i\in\Psi^s} \tilde{\alpha}_i^{s} = 1 \quad \wedge \quad \sum_{j\in\Psi^s} \tilde{\beta}_{ij}^{s} = 0 \tag{16}$$

Furthermore, to ensure linear homogeneity (16) and symmetry (17) in factor prices of the cost function, the factor demand system must satisfy the further parameter restrictions.

$$\sum_{j\in\Psi^s} \tilde{\beta}_{ij}^{s} = 0 \tag{17}$$

[7] This method to derive a factor demand system was first developed by Gollop (1974) and later applied in an article by Gollop; Roberts (1981) to estimate non-constant returns to scales for the U.S. electric power industry.

$$\tilde{\beta}^s_{ij} = \tilde{\beta}^s_{ji} \quad \textit{for all} \quad i, j \in \Phi^s \tag{18}$$

After the estimation of the parameters of the factor demand system, it is now possible to calculate the unobservable scale elasticity from equation (7) as well as the unbiased rate of cost diminuition from equation (8).

Data

We applied data for the U.S. from Jorgenson. However, because we are unable to account for quality changes in the three factor inputs for Germany, we adjusted the U.S. data so that quality changes are not separated from the real input quantities. We hope to be able to allow for this at a later stage of our research.

Furthermore, we adjusted the cap :al stocks of the U.S. data to exclude land and inventories because of unavailable data for Germany (for a detailed description of the U.S. data see Jorgenson; Gollop; Fraumeni, 1987).

The German data base uses data published by the Federal Statistic Office of Germany, the Institute of Labor Market Research (number of employees and effective working hours), capital stock data calculated by the German Institute for Economic Research (for a more detailed description of the data base see G. Erber, 1993).

To be able to express both sets of data in a common currency, the German data was converted by purchasing power parities (PPP) taken from Conrad (1985). For the method used to calculate specific PPPs for output and all three factor inputs see also Conrad (1985) or Erber (1993).

Since the base year for the price statistics differ in the U.S. and Germany, they were adjusted to a common base year. We have chosen 1980 as the base year for both countries so that the U.S. price deflators were adjusted t(have the same base as the German data.

The original data for the U.S. distinguish 35 industries which are very similar to the SIC sectoral breakdown of the officially published data. For Germany, the available sectoral breakdown distinguishes 51 industries. Since some sectoral definitions in the U.S. and Germany overlap, the corresponding industries were aggregated to get homogenous coverage for both countries. This process led to a 26 industry classification (see Erber 1993).

In the calculation of the German database, there were two industries for which difficulties arise in obtaining reasonable estimates for the wages and salaries to be attributed to the self-employed and helping family members. The first one is agriculture and the second one is furniture. These two industries were, therefore, excluded from this study. We hope, in the future that with correct adjustments, we will be able to include them in the next study.

Econometric Estimation and Testing of the Model

The two data sets were pooled to a two country panel data set of 50 observations (25 for each country). The necessary data for the growth rate of cost diminuition (the negative value of the growth rate of total factor productivity) and the differences in cost efficiency levels were obtained by using the standard Törnqvist index formulas.

The homogeneity condition was employed to transform the model in the course of the estimation process, so that relative price variables were used with the hourly wage price index as numéraire. This transformation reduces the multicollinearity between the prices variables as well as between the time trend and output variable. Therefore, the parameter estimates are less sensitive to biases of multicollinearity effects. The time trend variable was normalized to e(ual zero in the base year 1980.[8]

Note that the pooling of the data for the two countries to estimate non-constant returns to scale seems to be especially useful here as it increases the variance of the output variable substantially because of the different absolute sizes of the industries in the two economies. This helps to identify economies of scale considerably especially if they are close to unity as we will see below.

The model was estimated for 24 industries using a FIML estimation which imposed all necessary parameter restrictions to assure adding-up, homogeneity and symmetry (TSP 4.2B was the econometric program package applied). Note that the model is still linear in the parameters. Convergence of the estimation process occured after 5 to 10 iterations.

We refrained from using an instrumental variable estimation for the output variable. On the one hand, from an econometrians point of view, it should account for the potential endogeneity of the output variable (for the arguments and a way to select instrumental variables . ee Flaig; Steiner, 1993; Nakamura, 1992), on the other hand, it seems quite likely that if the instruments are not properly chosen, in other words they are not suffiently exogenous, they will distort the parameter estimates (cf. Hall, 1988, p. 932 or Basu; Fernald, 1992 p. 17 ff.). The chosen instruments by the two above mentioned studies however reduce the variance of the

[8] This procedure is especially useful under the condition of constant returns to scale since it gives an intuitive interpretation of the constant terms of the equations. It is less so under the condition of nonconstant returns to scale because the output variable is not normalized so that you have to sum up the constant term with the output term to obtain an estimate for the average cost share, rate of cost diminuition, etc.

output variable by making it smoother without removing the trend and, as a consequence, lead to a higher degree of collinearity between output and the time trend variable. Since the parameter estimates for the time and output variable seem to be quite sensitive to the collinearity between the two variables we refrained from introducing an instrument variable for output which might have increased collinearity between those two variables even further.[9]

For testing hypothesis, we used the Wald test for all combined hypothesis concerning two or more parameters or parameter combinations simultaneously. For testing hypothesis affecting only a single parameter, t-statistics were used. As a significance level to reject a hypothesis we always used 5%.

Table 1 summarizes the results for testing the hypothesis that constant returns or homogenous returns prevail. The former implies that all parameters in equation (7) are equal to zero, the latter that only the constant term might differ and the remaining parameters vary insignificantly from zero.

The first striking result is that the constant returns to scale hypothesis is rejected across all 24 industries. This conforms with outcomes of similar studies by Flaig; Steiner (1993) and Nakamura (1992). The first study, however, was restricted to German manufacturing industries using the same period from 1961 to 1985. The second study compared differences between four major U.S. and Japanese industries (chemicals, machinery, electrical, and transport) using a similar bilateral cost function approach but only introduced a homogenous returns to scale assumption. The findings also confirmed that the constant returns assumption is very restrictive.

The second result concerning the homogeneity assumption varies according to industry. In eleven industries, the assumption could not be rejected. These industries are mining, construction,apparel, rubber, leather, stone, fabricated metal,electrical machinery, motor vehicles, miscellaneous manufacturing, and utilities. For the remaining thirteen industries, the homogeneity assumption has to be rejected.

In table 1, we report the estimates of the scale elasticity of costs and its t-value if the model is estimated by restricting it to the homogenous returns to scale assumption. Note that if we were to have assumed only homogeneity of returns to scale, we would have accepted constant returns to scale for five industries (textiles, lumber, leather, primary metal, utilities). This result shows that time varying returns to scale, as implied by our bilateral factor demand system, are crucial in the decision as to whether to accept or reject constant returns to scale. If

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[9] A sensitivity analysis of this collinearity problem would help. We will undertake hopefully this exercise in the future.

Table 1

Testing *) Homogeneity and Constant Returns to Scale in the Bilateral Factor Demand System of the US and Germany by Industry

(1960–1985)

Industry	Constant Returns	Homogenous Returns	Scale Elasticity **)	National Differences
1 Agriculture				
2 Mining	rejected	accepted	0.54 (8.8)	rejected
3 Construction	rejected	accepted	0.87 (2.4)	accepted
4 Foods	rejected	rejected	0.84 (2.0)	rejected
5 Textiles	rejected	rejected	0.86 (1.7)	rejected
6 Apparel	rejected	accepted	0.89 (2.3)	rejected
7 Lumber	rejected	rejected	0.99 (0.1)	accepted
8 Furniture				
9 Paper	rejected	rejected	0.82 (2.7)	rejected
10 Printing	rejected	rejected	0.81 (6.2)	accepted
11 Chemicals	rejected	rejected	0.73 (53)	rejected
12 Petroleum	rejected	rejected	0.72 (5.2)	rejected
13 Rubber	rejected	accepted	0.88 (3.1)	rejected
14 Leather	rejected	accepted	0.87 (1.1)	rejected
15 Stone	rejected	accepted	0.84 (4.5)	rejected
16 Primary Metal	rejected	rejected	0.97 (0.5)	rejected
17 Fabricated Metal	rejected	accepted	0.84 (4.0)	rejected
18 Machinery	rejected	rejected	0.84 (3.6)	rejected
19 Electrical Machinery	rejected	accepted	0.85 (3.9)	rejected
20 Motor Vehicles	rejected	accepted	0.83 (7.2)	rejected
21 Transport Equipment	rejected	rejected	0.86 (3.0)	rejected
22 Precision Instruments	rejected	rejected	0.82 (3.6)	rejected
23 Miscellaneous Manufacturing	rejected	accepted	0.76 (3.6)	rejected
24 Utilities	rejected	accepted	0.86 (1.2)	rejected
25 Finance	rejected	rejected	0.62 (6.4)	accepted
26 Remaining Services incl. Government	rejected	rejected	0.75 (3.2)	rejected

*) scale elasticities of costs are estimated under the homogeneity assumption.
all tests use a 5% significance level.
**) values in brackets are t–values.

Source: own computations.

this possibility is excluded, it sometimes distorts the results, favouring the constant returns to scale assumption.

On average, one observes that the returns to scale are not very large (they never exceed the value of 2 or below 0.5 for the scale elasticity of costs respectively). The highest value found is for the mining industry. Here the opportunities offered by natural geological advantages for starting mining activities seem to be a central factor leading to high returns to scale. In other industries returns to scale are much closer to unity. However they seem to vary over time.

The last important observation reported in table 1 is that national differences are often not statistically supported. It was only in the case of four industries that we could accept the hypothesis that there are significant national differences in the scale elasticities.

In table 2, we report the average scale elasticities of costs and its standard deviations for each country separately. As one can see, there are substantial differences between both countries. They result, however, from differences in output levels and differences in relative factor prices. It is noteworthy that for two German industries the average scale elasticity even indicates decreasing returns to scale. For nineteen U.S. industries, the average scale elasticity is closer to unity than in the case of Germany. One might, therefore, speculate that one reason that the notion of increasing returns to scale found less support from U.S. data might stem from the fact that the U.S. economy utilized its potential of scale economies better than Germany. The standard argument for this result would be that the U.S. could utilize the larger size of its home market and, therefore, exhaust the potential of increasing returns to scale more rapidly.

Table 2

Biases of Technical Change in the Bilateral Factor Demand System for the US and the Federal Republic of Germany by Industry

(1960–1985)

Industry	Average	Stdev.	Average	Stdev.
1 Agriculture				
2 Mining	0.64	0.05	0.43	0.02
3 Construction	0.99	0.03	0.81	0.02
4 Foods	0.90	0.02	0.70	0.01
5 Textiles	0.95	0.03	0.93	0.02
6 Apparel	0.88	0.01	0.98	0.03
7 Lumber	0.87	0.03	1.33	0.02
8 Furniture				
9 Paper	0.89	0.00	0.73	0.00
10 Printing	0.89	0.04	0.67	0.01
11 Chemicals	0.80	0.03	0.67	0.03
12 Petroleum	0.72	0.05	0.84	0.09
13 Rubber	0.89	0.00	0.87	0.00
14 Leather	0.92	0.02	0.85	0.01
15 Stone	0.87	0.02	0.84	0.02
16 Primary Metal	0.96	0.04	1.11	0.08
17 Fabricated Metal	0.85	0.02	0.86	0.02
18 Machinery	0.89	0.03	0.86	0.05
19 Electrical Machinery	0.88	0.01	0.82	0.01
20 Motor Vehicles	0.82	0.02	0.83	0.05
21 Transport Equipment	0.85	0.01	0.81	0.01
22 Precision Instruments	0.87	0.02	0.80	0.01
23 Miscellaneous Manufacturing	0.90	0.04	0.68	0.03
24 Utilities	0.85	0.03	0.71	0.03
25 Finance	0.98	0.11	0.47	0.01
26 Remaining Services incl. Government	0.92	0.01	0.67	0.01

Source: based on own calculations.

To justify this statement, however, would necessitate furthermore detailed investigations, which we are unable to present currently.

Turning to the results obtained for the average rates of technological progress reported in table 3, one observes that the range for U.S. industries, excluding mining with 3.5%, is given by (-1%; 1.5%). Negative values only occur in five industries (Petroleum -1%, motor vehicles -0.3%, foods -0.2%, precision instrument -0.2%, utilities -0.1%). If one looks at the parameter estimates in table 10, one notices that the origins for them are different. The standard deviations for the rates of technological progress are substantially higher than for the scale elasticity. However, a detailed study cannot be presented here.

For Germany, we find that average rates of technological progress become negative much more often; this is offset by the higher scale elasticities compared to U.S. industries. The most striking results here are mining and finance. This might be due to multiicollinearity problems because both industries show, on average, extremely high scale elasticities which are compensate the negative rates of technological progress. Other unexpectedly low average rates of technological progress are found for construction, printing, chemicals, and utilities.

A more detailed study of the time varying rates of technological progress and the scale elasticities might help to determine why some of the less plausibel results occured. Special attention has to be given here to the collinearity problem which might influence the separation of the components considerably.

In the next step of our analysis, we are looking for significant permanent differences in cost structures for the industries in both countries. As can be seen from table 4, for fourteen industries there are statistically significant permanent differences in their cost structures. The industries affected by permanent differences in the cost structure are mining, foods, textiles, apparel, lumber, printing, chemicals, rubber, leather, machinery, motor vehicles, transport equipment, and miscellaneous manufacturing. With the exception of lumber, U.S. industries always have higher permanent cost shares for intermediate inputs (labeled in table 4 as material). This could be attributed to a greater degree of division of labour caused by differences in the size of U.S. and German industries. Where only labor cost shares are effected this seems to be a sensible explanation. Increased specialization of firms in a large economy compared to smaller ones might be one of the main reasons for the observed differences in permanent cost structures of U.S. and Geman industries. It will be interesting to see how the developent of the European Union and the current ongoing debate in Germany about implementing more rapidly concepts of lean production which were introduced earlier in the U.S. might stimulate a convergence in the currently observed permanent differences in cost structures.

Table 3

Average Percentage Rates of Technological Progress in the Bilateral Factor Demand System of the US and Germany by Industry

(1960–1985)

Industry	USA		Germany	
	Average	Stdev.	Average	Stdev.
1 Agriculture				
2 Mining	3.47	0.05	–4.82	0.07
3 Construction	1.19	0.24	–1.37	0.22
4 Foods	–0.21	0.27	0.05	0.23
5 Textiles	0.93	0.07	1.47	0.09
6 Apparel	0.42	0.31	1.65	0.28
7 Lumber	1.02	0.19	1.17	0.14
8 Furniture				
9 Paper	0.49	0.36	–0.31	0.33
10 Printing	1.07	0.16	–1.49	0.49
11 Chemicals	0.76	0.57	–1.56	0.22
12 Petroleum	–0.96	1.71	0.91	1.24
13 Rubber	0.19	0.24	0.83	0.18
14 Leather	0.74	0.22	0.58	0.15
15 Stone	1.18	0.26	0.07	0.20
16 Primary Metal	1.52	0.40	0.47	0.17
17 Fabricated Metal	0.72	0.22	0.53	0.20
18 Machinery	0.11	0.59	1.89	0.75
19 Electrical Machinery	0.53	0.13	1.45	0.03
20 Motor Vehicles	–0.31	0.21	–0.45	0.25
21 Transport Equipment	1.19	0.24	–0.14	0.26
22 Precision Instruments	–0.20	0.21	1.45	0.18
23 Miscellaneous Manufacturing	0.66	0.54	–0.01	0.42
24 Utilities	–0.13	0.44	–1.18	0.50
25 Finance	0.72	0.43	–4.21	0.30
26 Remaining Services Incl. Government	0.56	0.22	–1.14	0.21

Source: own computations.

Table 4

Equality or Inequality of Cost Structures in the Bilateral Factor Demand System of the US and the Federal Republic of Germany by Industry

(1960–1985)

Industry	Materials	Labor	Capital	Overall
1 Agriculture				
2 Mining	lower	equal	higher	unequal
3 Construction	equal	equal	equal	equal
4 Foods	higher	equal	lower	unequal
5 Textiles	higher	lower	lower	unequal
6 Apparel	higher	lower	equal	unequal
7 Lumber	lower	higher	equal	unequal
8 Furniture				
9 Paper	equal	equal	equal	equal
10 Printing	higher	lower	higher	unequal
11 Chemicals	higher	lower	equal	unequal
12 Petroleum	equal	equal	equal	equal
13 Rubber	higher	equal	lower	unequal
14 Leather	higher	lower	equal	unequal
15 Stone	equal	equal	equal	equal
16 Primary Metal	equal	equal	equal	equal
17 Fabricated Metal	equal	equal	equal	equal
18 Machinery	higher	lower	higher	unequal
19 Electrical Machinery	equal	equal	equal	equal
20 Motor Vehicles	higher	equal	lower	unequal
21 Transport Equipment	lower	equal	higher	unequal
22 Precision Instruments	equal	equal	equal	equal
23 Miscellaneous Manufacturing	higher	lower	equal	unequal
24 Utilities	equal	equal	equal	equal
25 Finance	equal	equal	equal	equal
26 Remaining Services incl. Government	equal	equal	equal	unequal

Source: own computations.

Finally, we now turn to augmentation of factors by biased technological progress. One important question here is if significant biases exist. Theoretically, we can distinguish thirteen different cases of technological progress for three factor inputs, which are summarized in table 5. To test for factor augmentation we used a Wald test to assure that at least two parameters are significantly different from zero because all three parameters characterizing the factor augmentation have to satisfy the condition to add up to zero.

$$\tilde{\beta}^{s}_{MT} + \tilde{\beta}^{s}_{LT} + \tilde{\beta}^{s}_{KT} = 0 \tag{19}$$

The parameters determining the non-neutrality of technological progress are obtained by taking the first derivatives of the cost share equation of the model with respect to the time trend variable. One obtains

$$\frac{\partial w_i^s}{\partial T} = \tilde{\beta}^{s}_{iT} \tag{20}$$

The estimates for the corresponding parameters are summarized in table 7 to 9 in the appendix.

In table 6, we report the results from the sequence of Wald tests which tested the following hypothesis

$$\begin{gathered} H_0^1 : \tilde{\beta}^{s}_{MT} = 0 \quad \wedge \quad \tilde{\beta}^{s}_{KT} = 0 \quad \wedge \quad \tilde{\beta}^{s}_{WT} = 0 \\ \textit{against} \\ G^1 : \tilde{\beta}^{s}_{MT} \neq 0 \quad \vee \quad \tilde{\beta}^{s}_{KT} \neq 0 \quad \vee \quad \tilde{\beta}^{s}_{LT} \neq 0. \end{gathered} \tag{21}$$

$$H_0^2 : \tilde{\beta}^{s}_{MT} = - \tilde{\beta}^{s}_{KT} \quad \wedge \quad \tilde{\beta}^{s}_{WT} = 0 \quad \textit{against} \quad G^2 : \tilde{\beta}^{s}_{MT} \neq -\tilde{\beta}^{s}_{KT} \quad \vee \quad \tilde{\beta}^{s}_{WT} \neq 0. \tag{22}$$

$$H_0^3 : \tilde{\beta}^{s}_{MT} = - \tilde{\beta}^{s}_{WT} \quad \wedge \quad \tilde{\beta}^{s}_{KT} = 0 \quad \textit{against} \quad G^3 : \tilde{\beta}^{s}_{MT} \neq -\tilde{\beta}^{s}_{WT} \quad \vee \quad \tilde{\beta}^{s}_{KT} \neq 0. \tag{23}$$

Table 5 - Biases of technical change in a three factor production possibility set.

	$\beta_{LT} < 0$			$\beta_{LT} = 0$			$\beta_{LT} > 0$		
	$\beta_{KT} < 0$	$\beta_{KT} = 0$	$\beta_{KT} > 0$	$\beta_{KT} < 0$	$\beta_{KT} = 0$	$\beta_{KT} > 0$	$\beta_{KT} < 0$	$\beta_{KT} = 0$	$\beta_{KT} > 0$
$\beta_{MT} < 0$			labor and material saving, capital using			capital using, material saving	labor using, capital and material saving	labor using, material saving	labor and capital using, material saving
$\beta_{MT} = 0$			labor saving, capital using		neutral technical change		labor using, capital saving		
$\beta_{MT} > 0$	labor and capital saving, material using	labor saving, material using	labor saving, capital and material using	capital saving, material using			labor and material using, capital saving		

$$H_0^4 : \tilde{\beta}^s_{KT} = - \tilde{\beta}^s_{WT} \quad \wedge \quad \tilde{\beta}^s_{MT} = 0 \quad \textit{against} \quad G^4 : \tilde{\beta}^s_{KT} \neq -\tilde{\beta}^s_{WT} \quad \vee \quad \tilde{\beta}^s_{MT} \neq 0. \tag{24}$$

For half of the industries in our study, we found that no statistical significant factor augmentation exists. For the other half, a general outcome is that technical change always uses intermediate inputs more intensily over time at the expense of labor and sometimes of capital as well (e.g. in stone and primary metal). Labor is always augmented if technical change is non-neutral. These findings are robust against the assumption concerning returns to scale because our previous study, Erber (1993), which assumed constant returns to scale for the bilateral cost function for the U.S. and Germany, revealed the same general observation.

Only three industries show a capital using technological progress. In printing, it is material and capital using and labor saving. In miscellaneous manufacturing, it is labour saving and capital using leaving intermediate inputs unchanged, and finally, in the remaining services including government, it is the same augmentation process as in miscellaneous manufacturing. Therefore, the observed different types of factor augmenting technological progress are significantly less than are, in principle, possible. This leaves the following question unanswered: Why is factor augmentation much more restricted in our empirical study as would be theoretically possible?

Table 6

Biases of Technical Change in the Bilateral Factor Demand System for the US and the Federal Republic of Germany by Industry

(1960–1985)

Industry	Materials	Labor	Capital	Overall
1 Agriculture				
2 Mining	using	saving	neutral	biased
3 Construction	neutral	neutral	neutral	neutral
4 Foods	neutral	neutral	neutral	neutral
5 Textiles	using	saving	neutral	biased
6 Apparel	neutral	neutral	neutral	neutral
7 Lumber	neutral	neutral	neutral	neutral
8 Furniture				
9 Paper	using	saving	neutral	biased
10 Printing	using	saving	using	biased
11 Chemicals	neutral	neutral	neutral	neutral
12 Petroleum	neutral	neutral	neutral	neutral
13 Rubber	using	saving	neutral	biased
14 Leather	using	saving	neutral	biased
15 Stone	using	saving	saving	biased
16 Primary Metal	using	neutral	saving	biased
17 Fabricated Metal	neutral	neutral	neutral	neutral
18 Machinery	neutral	neutral	neutral	neutral
19 Electrical Machinery	neutral	neutral	neutral	neutral
20 Motor Vehicles	neutral	neutral	neutral	neutral
21 Transport Equipment	using	saving	neutral	biased
22 Precision Instruments	neutral	neutral	neutral	neutral
23 Miscellaneous Manufacturing	neutral	saving	using	biased
24 Utilities	using	saving	neutral	biased
25 Finance	neutral	neutral	neutral	neutral
26 Remaining Services incl. Government	neutral	saving	using	biased

Source: based on own calculations.

Conclusions

What has been accomplished by this study?

Firstly, if we use the current data set, we find overwhelming evidence in favor of increasing returns to scale. However, one should be cautious, for a number of reasons, in concluding that our results are already a final proof of what everybody is searching for in the debate on the significance of increasing returns to scale.

One reason for this is that we have not accounted for quality changes in our factor inputs. Changing this might, to some extent, change the results. Future studies will show how much quality changes matter. Furthermore, using working hours as labor inputs does not appropriately account for human capital. Changing the labor input from working hours to human capital would be more in line with the current debate about increasing returns. There is ample space for a debate on human capital and how to define it appropriately.

A second reason is that a cautious study of impacts of collinearity on the parameter estimates of the two components, scale elasticity and rate of technological progress might reveal some fragility of the estimates. Some of our results at times cast doubt on their own economic significance, possibly due to the collinearity problem. A thorough study of these problems has yet to be done.

Thirdly, the model has such a large number of parameters, that even 50 observations are not suffient enough to guarantee that results might not change if the sample size were to be increased. We will find out when our time period is extended to 1989. One way to increase the sample size considerably besides adding further annual data for the two countries, would be by including more countries (we plan to include Japan in our study). This seems to be especially promising because of the differences in absolute size of their industries. This will not only substantially increase the number of observations but also the variance of the output variable. This will help to discriminate scale effects from impacts of technological change especially if they are close to unity.

A further major result of this study is that it confirms the results of a previous study based on the constant returns to scale assumption (cf. Erber, 1993) that technological change - if it is non-neutral - tends to be always labor saving and most likely intermediate input using at the same time. This might, to a large extent, be attributed to increased division of labor.

Another important conclusion - apparently closely linked to this - is that in a considerable number of industries there exists significant differences in cost structures for both countries industries. However, if these are related to higher specilization because the countries are facing a larger domestic market, why does this matter more in some industries and less in others?

Finally, we have made little progress in identifying sources of returns to scale, even if they robust when better data, including quality changes and appropriately measured human capital, is available. The question of their correct embodiment in single factors is still unsolved. Ofcause a dimishing rate of TFP growth caused by accounting for quality changes will already reduce the magnitude of the Solow residual - and we should keep in mind that it is still suites as a catch all variable - but the question as to how to embody returns to scale and technological progress in a meaningful way to some factors remains important.

Furthermore, the introduction of some externalities like R&D or public infrastructure besides the time trend might help to find additional real world variables to account for it.

As a last word I would like to point out that the possibility to establish increasing returns to scale as an empirical fact in its present form will not contribute to determining whether or not endogenous growth theories are empirically valid. As Solow (1994) mentioned recently in summarizing the debate on growth theories:

"Notice that I have not mentioned constant returns to scale. That is because the model can get along perfectly well without constant returns to scale. The occasional expression of belief to the contrary is just a misconception. The assumption of constant returns to scale is a considerable simplification. (p. 48) ... It is perfectly possible to have increasing returns to scale and preserve all the standard neoclassical results. What is essential is the assumption of constant returns to capital. (p. 49)."

This defines a new research strategy to introduce an embodiment of scale elasticities to factor inputs for flexible functional forms which are used nowadays and which proved quite superior to the traditional Cobb-Douglas function approach.

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Appendix

Table 7

Estimates for the intermediate input share equation *) in the bilateral factor demand system of the US and the Federal Republic of Germany by industry

(1960–1985)

Industry	alpha(M) (t-value)	beta(MM) (t-value)	beta(MK) (t-value)	beta(MW) (t-value)	beta(MT) (t-value)	beta(MD) (t-value)	beta(MQ) (t-value)	R^2 DW
1 Agriculture								
2 Mining	−0.086	0.168	−0.056	−0.112	0.002	−0.269	0.062	0.95
	(−0.1)	(3.6)	(−2.8)	(−2.9)	(3.6)	(−2.3)	(1.0)	1.16
3 Construction	1.010	0.051	−0.041	−0.010	0.000	0.071	−0.041	0.87
	(1.0)	(1.0)	(−2.3)	(−0.2)	(−0.6)	(1.4)	(−0.5)	0.47
4 Foods	−0.068	0.111	−0.035	−0.076	0.000	0.062	0.064	0.70
	(−0.1)	(3.8)	(−2.2)	(−3.3)	(0.1)	(2.4)	(1.0)	0.62
5 Textiles	1.280	0.097	−0.030	−0.067	0.003	0.149	−0.066	0.95
	(3.4)	(2.5)	(−1.5)	(−4.0)	(3.7)	(8.2)	(−1.9)	0.84
6 Apparel	1.096	0.091	−0.025	−0.066	0.001	0.076	−0.048	0.61
	(4.0)	(2.1)	(−1.4)	(−2.7)	(0.8)	(2.6)	(−1.8)	0.74
7 Lumber	−0.244	0.143	−0.031	−0.112	0.001	−0.243	0.102	0.98
	(−1.0)	(5.9)	(−4.5)	(−4.0)	(1.5)	(−6.7)	(3.7)	1.09
8 Furniture								
9 Paper	0.189	0.162	−0.036	−0.126	0.004	−0.030	0.044	0.90
	(0.4)	(2.8)	(−1.6)	(−3.6)	(3.3)	(−0.7)	(1.0)	0.64
10 Printing	1.354	0.037	−0.017	−0.020	0.005	0.156	−0.087	0.93
	(4.4)	(1.4)	(−1.1)	(−2.2)	(5.8)	(4.6)	(−2.8)	1.10
11 Chemicals	−0.160	0.135	−0.037	−0.098	0.004	0.069	0.065	0.86
	(−0.3)	(3.5)	(−1.3)	(−2.9)	(1.2)	(2.2)	(1.2)	0.40
12 Petroleum	0.366	0.083	−0.057	−0.026	0.001	0.006	0.043	0.83
	(0.5)	(3.5)	(−4.5)	(−1.9)	(0.5)	(0.1)	(0.6)	0.71
13 Rubber	0.729	0.088	−0.005	−0.083	0.006	0.075	−0.013	0.89
	(2.5)	(1.6)	(−0.2)	(−4.0)	(4.9)	(4.0)	(−0.5)	0.81
14 Leather	0.538	0.242	−0.036	−0.206	0.003	0.025	0.003	0.69
	(1.1)	(5.4)	(−3.3)	(−5.7)	(1.7)	(1.5)	(0.1)	1.25
15 Stone	0.485	0.025	−0.010	−0.015	0.003	0.000	0.733	0.80
	(0.8)	(0.3)	(−0.5)	(−0.0)	(3.0)	(0.0)	(0.1)	0.30
16 Primary Metal	−0.244	0.089	−0.007	−0.082	0.003	−0.049	0.082	0.92
	(1.0)	(4.9)	(−0.8)	(−2.3)	(5.3)	(−1.8)	(3.6)	1.10
17 Fabricated Metal	0.787	0.099	−0.006	−0.093	0.003	0.021	−0.021	0.25
	(1.4)	(2.8)	(−0.3)	(−3.1)	(2.1)	(0.8)	(−0.4)	0.32
18 Machinery	−0.079	0.211	−0.025	−0.186	0.003	0.037	0.049	0.83
	(−0.2)	(3.2)	(−2.0)	(−3.6)	(1.7)	(1.3)	(1.6)	0.65
19 Electrical Machinery	0.675	0.078	−0.001	−0.077	0.003	0.009	−0.012	0.86
	(1.5)	(5.3)	(−0.1)	(−11.8)	(1.5)	(1.0)	(−0.3)	1.15
20 Motor Vehicles	0.866	0.061	−0.020	−0.041	0.003	0.145	−0.020	0.87
	(2.5)	(1.3)	(−1.9)	(−1.0)	(1.8)	(3.8)	(−0.7)	0.77
21 Transport Equipment	0.074	0.150	−0.004	−0.146	0.003	−0.070	0.049	0.70
	(0.4)	(8.4)	(−0.5)	(−8.2)	(4.2)	(−1.7)	(2.4)	0.73
22 Precision Instruments	0.154	0.174	−0.028	−0.146	0.003	0.010	0.030	0.80
	(0.7)	(8.6)	(−3.7)	(−4.6)	(1.9)	(0.4)	(1.3)	0.98
23 Miscellaneous Manufacturing	−0.267	0.129	−0.035	−0.094	0.000	0.104	0.076	0.64
	(−0.6)	(3.4)	(−2.5)	(−2.0)	(0.7)	(3.1)	(1.9)	0.61
24 Utilities	0.975	0.071	−0.065	−0.006	0.009	−0.017	−0.027	0.90
	(0.9)	(1.2)	(−1.2)	(−1.7)	(1.7)	(−0.2)	(−0.3)	0.33
25 Finance	2.354	0.013	−0.041	0.028	0.005	0.098	−0.166	0.89
	(2.5)	(0.6)	(−2.5)	(−0.1)	(1.7)	(1.7)	(−2.1)	0.71
26 Remaining Services incl. Government	−0.345	0.189	−0.082	−0.107	0.001	−0.036	0.053	0.96
	(−0.3)	(5.0)	(−3.3)	(−3.7)	(0.3)	(−1.1)	(0.7)	0.36

*) vsh = alpha + beta(MM) * ln p(M) + beta(MK) * ln p(K) + beta(MW) * ln p(W) + beta(MT) * time + beta(MD) * D(US) + beta(MQ) * ln Q.

Source: own computations.

Table 8

Estimates for the capital share equation *) in the bilateral factor demand system of the US and the Federal Republic of Germany by industry

(1960–1985)

Industry	alpha(K) (t-value)	beta(KM) (t-value)	beta(KK) (t-value)	beta(KW) (t-value)	beta(KT) (t-value)	beta(KD) (t-value)	beta(KQ) (t-value)	R^2 DW
1 Agriculture								
2 Mining	0.633	−0.056	0.069	−0.013	0.001	0.396	−0.053	0.99
	(1.0)	(−2.8)	(2.9)	(−1.0)	(1.3)	(3.4)	(−0.9)	0.83
3 Construction	−0.089	−0.041	0.059	−0.018	0.001	−0.004	0.014	0.94
	(−0.3)	(−0.5)	(8.7)	(−1.3)	(1.3)	(−0.3)	(0.6)	0.52
4 Foods	0.614	−0.035	0.048	−0.013	0.001	−0.026	−0.042	0.84
	(1.8)	(−2.2)	(5.0)	(−1.0)	(2.0)	(−2.1)	(−1.5)	1.10
5 Textiles	−0.550	−0.030	0.043	−0.013	−0.002	−0.055	0.063	0.83
	(−1.3)	(−1.5)	(2.2)	(−1.6)	(−1.7)	(−5.1)	(1.8)	0.58
6 Apparel	−0.410	−0.025	0.026	−0.001	0.000	−0.047	0.046	0.86
	(2.1)	(−2.0)	(2.2)	(−0.1)	(0.1)	(−2.1)	(2.3)	0.92
7 Lumber	−0.292	−0.031	0.045	−0.014	0.000	0.017	0.037	0.93
	(−1.3)	(−4.5)	(11.4)	(−1.9)	(0.2)	(0.5)	(1.5)	1.06
8 Furniture								
9 Paper	0.088	−0.036	0.054	−0.018	−0.001	−0.020	0.003	0.82
	(0.3)	(−1.6)	(3.6)	(−1.1)	(−0.5)	(−0.8)	(0.1)	0.77
10 Printing	0.694	−0.017	0.047	−0.030	0.003	0.088	−0.060	0.64
	(2.4)	(−1.1)	(3.9)	(−2.9)	(2.8)	(2.3)	(−2.0)	0.82
11 Chemicals	0.299	−0.037	0.065	−0.028	−0.002	−0.005	−0.014	0.94
	(0.5)	(−1.3)	(2.3)	(−2.7)	(−0.8)	(−0.2)	(−0.3)	0.71
12 Petroleum	0.473	−0.057	0.057	0.000	0.001	−0.013	−0.032	0.83
	(0.8)	(−4.5)	(5.7)	(0.0)	(0.3)	(−0.3)	(−0.6)	0.98
13 Rubber	−0.091	−0.005	0.047	−0.042	−0.001	−0.066	0.015	0.97
	(−0.4)	(−0.2)	(3.3)	(−2.0)	(−0.5)	(−3.8)	(0.7)	0.73
14 Leather	−0.141	−0.036	0.032	0.004	0.001	0.010	0.022	0.66
	(−0.3)	(−3.3)	(2.3)	(0.5)	(0.7)	(0.8)	(0.4)	1.08
15 Stone	0.001	−0.010	0.038	−0.028	−0.002	−0.016	0.010	0.82
	(0.0)	(−0.5)	(2.0)	(−1.8)	(−1.7)	(−1.0)	(0.2)	0.43
16 Primary Metal	−0.404	−0.007	0.022	−0.015	−0.002	0.027	0.037	0.89
	(−2.5)	(−0.8)	(3.6)	(−1.4)	(−3.5)	(1.1)	(2.5)	0.93
17 Fabricated Metal	−0.677	−0.006	0.031	−0.025	−0.001	−0.019	0.068	0.33
	(−1.2)	(−0.3)	(1.8)	(−2.1)	(−0.9)	(−0.6)	(1.3)	0.54
18 Machinery	−0.321	−0.025	0.030	−0.005	−0.003	0.017	0.034	0.71
	(−0.8)	(−2.0)	(2.3)	(−0.4)	(−1.6)	(1.5)	(1.0)	0.91
19 Electrical Machinery	−0.147	−0.001	0.022	−0.021	−0.001	0.007	0.019	0.42
	(−0.3)	(−0.1)	(1.6)	(−3.6)	(−0.3)	(0.7)	(0.4)	1.01
20 Motor Vehicles	0.227	−0.020	0.032	−0.012	−0.002	−0.093	−0.013	0.80
	(0.6)	(−1.9)	(2.6)	(−1.1)	(−1.7)	(−2.4)	(−0.4)	1.30
21 Transport Equipment	−0.070	−0.004	0.020	−0.016	−0.001	−0.048	0.012	0.60
	(−0.3)	(−0.5)	(2.7)	(−3.3)	(−0.5)	(−0.9)	(0.5)	0.91
22 Precision Instruments	−0.412	−0.028	0.039	−0.011	−0.004	−0.014	0.050	0.64
	(−1.0)	(−3.7)	(4.4)	(−1.7)	(−1.7)	(−0.5)	(1.2)	0.88
23 Miscellaneous Manufacturing	0.277	−0.035	0.047	−0.012	0.001	−0.001	−0.018	0.79
	(0.8)	(−2.5)	(6.4)	(−1.1)	(1.8)	(−0.1)	(−0.8)	1.33
24 Utilities	1.180	−0.065	0.064	0.001	−0.002	0.091	−0.086	0.91
	(0.8)	(−1.2)	(1.7)	(0.0)	(−0.3)	(1.3)	(0.7)	0.54
25 Finance	0.232	−0.041	0.147	−0.106	0.000	−0.078	0.011	0.99
	(0.1)	(−2.5)	(6.5)	(−4.4)	(0.0)	(−0.7)	(0.1)	0.62
26 Remaining Services incl. Government	2.311	−0.082	0.132	−0.050	0.007	−0.003	−0.151	0.91
	(2.9)	(−3.3)	(7.7)	(−2.4)	(2.8)	(−0.2)	(−2.7)	0.87

*) ksh = alpha + beta(KM) * ln p(M) + beta(KK) * ln p(K) + beta(KW) * ln p(W) + beta(KT) * time + beta(KD) * D(US) + beta(KQ) * ln Q.
Source: own computations.

Table 9

Estimates for the wage cost share equation *) in the bilateral factor demand system of the US and the Federal Republic of Germany by industry

(1960–1985)

Industry	alpha(W) (t-value)	beta(WM) (t-value)	beta(WK) (t-value)	beta(WW) (t-value)	beta(WT) (t-value)	beta(WD) (t-value)	beta(WQ) (t-value)	R^2 DW
1 Agriculture								
2 Mining	0.453	−0.112	−0.013	0.125	−0.003	−0.127	0.009	
	(0.7)	(−3.0)	(−1.0)	(3.1)	(−3.3)	(−1.2)	(−0.1)	
3 Construction	0.079	−0.010	−0.018	0.028	−0.001	−0.067	0.027	
	(0.1)	(−0.2)	(−1.3)	(0.6)	(−0.2)	(−1.3)	(0.3)	
4 Foods	0.454	−0.076	−0.013	0.089	−0.001	−0.036	−0.022	
	(0.5)	(−2.9)	(−1.0)	(3.0)	(−1.1)	(−1.2)	(−0.3)	
5 Textiles	0.270	−0.067	−0.013	0.080	−0.001	−0.094	0.003	
	(1.1)	(−2.5)	(−1.6)	(3.7)	(−3.3)	(−6.7)	(0.1)	
6 Apparel	0.314	−0.066	−0.001	0.067	−0.001	−0.029	0.002	
	(1.5)	(−2.1)	(−0.1)	(2.5)	(−1.3)	(−1.8)	(0.1)	
7 Lumber	1.536	−0.112	−0.014	0.126	−0.001	0.226	−0.139	
	(5.2)	(−5.1)	(−1.9)	(6.0)	(−1.2)	(5.2)	(−4.3)	
8 Furniture								
9 Paper	0.723	−0.126	−0.018	0.144	−0.003	0.050	−0.046	
	(1.6)	(−3.2)	(−1.1)	(4.8)	(−2.6)	(1.3)	(−1.1)	
10 Printing	−1.048	−0.020	−0.030	0.050	−0.008	−0.244	0.146	
	(−3.1)	(−1.5)	(−2.9)	(5.2)	(−7.2)	(−6.0)	(4.3)	
11 Chemicals	0.861	−0.098	−0.028	0.126	−0.002	−0.064	−0.051	
	(2.1)	(−2.4)	(−2.7)	(3.3)	(−1.5)	(−2.7)	(−1.5)	
12 Petroleum	0.161	−0.026	0.000	0.026	−0.002	0.007	−0.010	
	(0.5)	(−1.9)	(0.0)	(2.3)	(−2.2)	(0.4)	(−0.4)	
13 Rubber	0.362	−0.083	−0.042	0.125	−0.005	−0.009	−0.001	
	(1.3)	(−2.1)	(−2.0)	(3.5)	(−3.3)	(−0.3)	(−0.1)	
14 Leather	0.603	−0.206	0.004	0.201	−0.004	−0.035	−0.026	
	(1.5)	(−4.7)	(0.5)	(4.7)	(−2.6)	(−2.3)	(−0.6)	
15 Stone	0.514	−0.015	−0.028	0.043	−0.001	0.016	−0.018	
	(1.0)	(−0.2)	(−1.8)	(0.6)	(−1.2)	(0.4)	(−0.4)	
16 Primary Metal	1.648	−0.082	−0.015	0.097	−0.001	0.022	−0.120	
	(5.9)	(−5.6)	(−1.3)	(6.9)	(−0.9)	(0.6)	(−4.5)	
17 Fabricated Metal	0.890	−0.093	−0.025	0.118	−0.002	−0.002	−0.002	
	(1.7)	(−3.7)	(−2.1)	(4.6)	(−2.1)	(−1.2)	(−1.0)	
18 Machinery	1.400	−0.186	−0.005	0.191	0.000	−0.054	−0.083	
	(5.7)	(−3.4)	(−0.4)	(3.6)	(0.0)	(−2.5)	(4.0)	
19 Electrical Machinery	0.472	−0.077	−0.021	0.098	−0.002	−0.016	−0.007	
	(1.9)	(−8.6)	(−3.6)	(9.0)	(−2.0)	(−2.4)	(−0.3)	
20 Motor Vehicles	−0.093	−0.041	−0.012	0.053	−0.001	−0.052	0.033	
	(−0.2)	(−0.9)	(−1.1)	(1.2)	(−0.5)	(−1.4)	(1.0)	
21 Transport Equipment	0.996	−0.146	−0.016	0.162	−0.002	0.118	−0.061	
	(4.4)	(−8.3)	(−3.3)	(8.2)	(−2.0)	(2.4)	(−2.5)	
22 Precision Instruments	1.258	−0.146	−0.011	0.157	0.001	0.004	−0.080	
	(4.4)	(−6.4)	(−1.6)	(6.4)	(0.6)	(0.2)	(−2.8)	
23 Miscellaneous Manufacturing	0.990	−0.094	−0.012	0.106	−0.001	−0.103	−0.059	
	(2.6)	(−3.3)	(−1.0)	(5.0)	(−2.8)	(−4.3)	(−1.7)	
24 Utilities	−1.155	−0.006	0.001	0.005	−0.007	−0.074	0.113	
	(−1.5)	(−0.2)	(0.2)	(0.1)	(−4.1)	(−3.2)	(1.7)	
25 Finance	−1.586	0.028	−0.106	0.078	−0.005	−0.020	0.155	
	(−1.0)	(1.1)	(−4.4)	(2.1)	(−0.9)	(−0.2)	(1.1)	
26 Remaining Services incl. Government	−0.966	−0.107	−0.050	0.157	−0.008	0.039	0.097	
	(−0.8)	(−3.8)	(−2.4)	(4.9)	(−2.6)	(1.3)	(1.1)	

*) wsh = alpha + beta(WM) * ln p(M) + beta(WK) * ln p(K) + beta(WW) * ln p(W) + beta(WT) * time + beta(WD) * D(US) + beta(WQ) * ln Q.
Source: own computations.

Table 10

Estimates for the elasticity of cost diminuition *) in the bilateral factor demand system of the US and the Federal Republic of Germany by industry

(1960–1985)

Industry	alpha(T) (t-value)	beta(TM) (t-value)	beta(TK) (t-value)	beta(TW) (t-value)	beta(TT) (t-value)	beta(TD) (t-value)	beta(TQ) (t-value)	R^2 DW
1 Agriculture								
2 Mining	−0.089	0.002	0.001	−0.003	0.000	0.075	0.005	0.69
	(−0.8)	(3.7)	(1.3)	(−3.3)	(0.1)	(3.4)	(0.5)	1.23
3 Construction	0.050	0.000	0.001	−0.001	−0.022	0.030	−0.005	0.26
	(1.0)	(−0.6)	(1.3)	(−0.2)	(−0.4)	(6.0)	(−1.2)	1.18
4 Foods	0.058	0.000	0.001	−0.001	0.000	0.000	−0.005	0.22
	(0.6)	(0.1)	(2.0)	(−1.1)	(−0.3)	(−0.0)	(−0.6)	1.60
5 Textiles	0.015	0.003	−0.002	−0.001	0.000	−0.700	−0.003	0.00
	(0.3)	(3.7)	(−1.7)	(−3.3)	(0.0)	(−0.5)	(−0.4)	2.16
6 Apparel	−0.028	0.001	0.000	−0.001	0.000	−0.013	0.002	0.10
	(−1.2)	(0.8)	(0.1)	(−1.3)	(−1.0)	(−4.1)	(0.9)	2.27
7 Lumber	−0.078	0.001	0.000	−0.001	0.000	−0.011	0.007	0.06
	(−2.9)	(1.5)	(0.2)	(−1.2)	(−0.3)	(−2.0)	(2.5)	2.77
8 Furniture								
9 Paper	−0.022	0.004	−0.001	−0.003	0.000	0.008	0.001	0.40
	(−0.7)	(3.3)	(−0.5)	(−2.6)	(−0.6)	(1.6)	(0.4)	2.23
10 Printing	0.021	0.005	0.003	−0.008	0.001	0.034	−0.003	0.49
	(0.4)	(5.8)	(2.8)	(−7.2)	(1.4)	(4.7)	(−0.7)	2.02
11 Chemicals	0.216	0.004	−0.002	−0.002	0.001	0.029	−0.019	0.50
	(1.2)	(1.2)	(−0.8)	(−1.5)	(0.4)	(1.8)	(−1.3)	1.42
12 Petroleum	0.342	0.001	0.001	−0.002	0.001	0.013	−0.031	0.48
	(2.6)	(0.5)	(0.3)	(−2.2)	(−0.4)	(0.7)	(−2.5)	1.71
13 Rubber	−0.017	0.006	−0.001	−0.005	0.000	−0.005	0.001	0.26
	(−0.2)	(4.9)	(−0.5)	(−3.3)	(−0.2)	(−0.7)	(0.1)	2.12
14 Leather	−0.064	0.003	0.001	−0.004	0.000	0.004	0.006	0.12
	(−0.3)	(1.7)	(0.7)	(−2.6)	(0.0)	(0.8)	(0.3)	2.23
15 Stone	0.041	0.003	−0.002	−0.001	0.000	0.012	−0.005	0.52
	(0.6)	(3.0)	(−1.7)	(−1.2)	(−0.4)	(4.1)	(−0.8)	1.28
16 Primary Metal	0.033	0.003	−0.002	−0.001	0.000	0.012	−0.005	0.01
	(0.6)	(5.3)	(−3.5)	(−0.9)	(−0.3)	(2.0)	(−0.8)	1.74
17 Fabricated Metal	0.008	0.003	−0.001	−0.002	0.000	0.003	−0.002	0.38
	(0.2)	(2.1)	(−0.9)	(−1.2)	(−0.3)	(0.6)	(−0.4)	1.93
18 Machinery	0.174	0.003	−0.003	0.000	0.000	−0.017	−0.015	0.50
	(1.5)	(1.7)	(−1.6)	(−0.3)	(−0.4)	(−3.4)	(−1.5)	0.94
19 Electrical Machinery	0.006	0.003	−0.001	−0.002	0.000	−0.008	−0.001	0.40
	(0.1)	(1.5)	(−0.3)	(−2.0)	(0.1)	(−1.2)	(−0.1)	1.53
20 Motor Vehicles	−0.127	0.003	−0.002	−0.001	−0.001	0.008	0.011	0.77
	(−2.0)	(1.8)	(−1.7)	(−0.5)	(−1.3)	(1.6)	(2.0)	1.52
21 Transport Equipment	−0.038	0.003	−0.001	−0.002	0.000	0.009	0.003	0.39
	(−1.4)	(4.2)	(−0.5)	(−2.0)	(0.4)	(1.1)	(1.0)	1.74
22 Precision Instruments	0.112	0.003	−0.004	0.001	0.001	−0.012	−0.011	0.33
	(0.9)	(1.9)	(−1.8)	(0.6)	(0.6)	(−0.9)	(−0.9)	1.48
23 Miscellaneous Manufacturing	0.069	0.000	0.001	−0.001	0.000	0.005	−0.008	0.47
	(0.6)	(0.7)	(1.8)	(−2.8)	(−0.4)	(1.2)	(−0.7)	1.81
24 Utilities	0.206	0.009	−0.002	−0.007	0.001	0.032	−0.018	0.22
	(0.8)	(1.7)	(−0.3)	(−4.1)	(0.6)	(2.3)	(−0.8)	1.33
25 Finance	0.015	0.005	0.000	−0.005	0.000	0.053	−0.002	0.49
	(0.1)	(1.7)	(0.1)	(−0.9)	(−0.2)	(3.3)	(−0.1)	1.64
26 Remaining Services incl. Government	0.075	0.001	0.007	−0.008	0.001	0.015	−0.005	0.45
	(0.5)	(0.3)	(2.8)	(−2.6)	(1.2)	(1.8)	(−0.5)	1.72

*) −g(T) = alpha + beta(TM)*ln p(M) + beta(TK)*ln p(K) + beta(TW)*ln p(W) + beta(TT)*time + beta(TD)*D(US) + beta(TQ) * ln Q.
Source: own computations.

Table 11

Estimates for the relative difference in cost efficiency levels elasticity *) in the bilateral factor demand system of the US and the Federal Republic of Germany by Industry

(1960–1985)

Industry	alpha(D) (t-value)	beta(DM) (t-value)	beta(DK) (t-value)	beta(DW) (t-value)	beta(DT) (t-value)	beta(DD) (t-value)	beta(DQ) (t-value)	R^2 DW
1 Agriculture								
2 Mining	28.057	−0.269	0.396	−0.127	0.075	3.000	−2.603	0.88
	(2.0)	(−2.3)	(3.4)	(−1.2)	(3.4)	(1.4)	(−1.9)	0.42
3 Construction	6.003	0.071	−0.004	−0.067	0.030	0.402	−0.517	0.90
	(2.3)	(1.4)	(−0.3)	(−1.3)	(6.0)	(1.2)	(−2.3)	0.50
4 Foods	4.799	0.062	−0.026	−0.036	0.000	0.075	−0.413	0.77
	(1.4)	(2.4)	(−2.1)	(−1.2)	(−0.0)	(0.2)	(−1.3)	0.96
5 Textiles	0.916	0.149	−0.055	−0.094	−0.700	0.007	−0.113	0.51
	(0.4)	(8.2)	(−5.1)	(−6.7)	(−0.5)	(0.0)	(−0.4)	0.76
6 Apparel	−0.140	0.076	−0.047	−0.029	−0.013	−0.310	0.048	0.93
	(−0.1)	(2.7)	(−2.1)	(−1.8)	(−4.1)	(−1.6)	(0.3)	0.89
7 Lumber	−5.485	−0.243	0.017	0.226	−0.011	−1.331	0.667	0.48
	(−2.7)	(−6.7)	(0.5)	(5.2)	(−2.0)	(−2.9)	(2.9)	1.12
8 Furniture								
9 Paper	2.458	−0.030	−0.020	0.050	0.008	−0.002	−0.243	0.36
	(1.7)	(−0.7)	(−0.8)	(1.3)	(1.6)	(−0.1)	(−1.6)	1.20
10 Printing	5.538	0.156	0.088	−0.244	0.034	0.546	−0.528	0.95
	(2.8)	(4.6)	(2.3)	(−6.0)	(−4.7)	(1.7)	(−2.2)	0.96
11 Chemicals	2.840	0.069	−0.005	−0.064	0.029	−0.195	−0.248	0.63
	(0.7)	(2.2)	(−0.2)	(−2.7)	(1.8)	(−1.0)	(−0.7)	0.41
12 Petroleum	4.170	0.006	−0.013	0.007	0.013	−0.406	−0.326	0.01
	(0.7)	(0.1)	(−0.3)	(0.4)	(0.7)	(−0.5)	(−0.8)	0.31
13 Rubber	0.486	0.075	−0.066	−0.009	−0.005	−0.201	0.000	0.35
	(0.4)	(4.0)	(−3.8)	(−0.3)	(−0.7)	(−1.4)	(0.0)	0.88
14 Leather	0.689	0.025	0.010	−0.035	0.004	−0.062	−0.062	0.09
	(0.3)	(1.5)	(0.6)	(−2.3)	(0.6)	(−0.3)	(−0.3)	1.25
15 Stone	0.396	0.000	−0.016	0.016	0.012	−0.174	−0.040	0.73
	(0.3)	(0.0)	(−1.0)	(0.4)	(4.1)	(−1.7)	(−0.3)	0.61
16 Primary Metal	−2.281	−0.049	0.027	0.022	0.012	−0.224	0.201	0.49
	(−1.0)	(−1.8)	(1.1)	(0.6)	(2.0)	(−0.8)	(1.0)	0.81
17 Fabricated Metal	−0.084	0.021	−0.019	−0.002	0.003	−0.271	0.020	0.11
	(−0.1)	(0.8)	(−0.6)	(−0.1)	(0.6)	(−1.3)	(0.1)	0.43
18 Machinery	0.119	0.037	0.017	−0.054	−0.017	−0.131	−0.018	0.89
	(0.1)	(1.3)	(1.5)	(−2.5)	(−3.4)	(−1.5)	(−0.2)	0.69
19 Electrical Machinery	0.777	0.009	0.007	−0.016	−0.008	−0.138	−0.072	0.84
	(0.6)	(1.0)	(0.7)	(−2.3)	(−1.2)	(−1.6)	(−0.7)	0.61
20 Motor Vehicles	−0.746	0.145	−0.093	−0.052	0.008	0.052	0.050	0.62
	(−0.6)	(3.8)	(−2.5)	(−1.4)	(1.6)	(0.4)	(0.5)	1.14
21 Transport Equipment	−0.251	−0.070	−0.[illegible]48	0.118	0.009	−0.683	0.076	0.71
	(−0.2)	(−1.6)	(−0.[illegible])	(2.4)	(1.1)	(−1.5)	(0.6)	0.33
22 Precision Instruments	1.960	0.010	−0.014	0.004	−0.012	−0.168	−0.192	0.94
	(0.8)	(0.4)	(−0.5)	(0.2)	(−0.8)	(−0.5)	(−0.7)	0.70
23 Miscellaneous Manufacturing	0.425	0.104	−0.001	−0.103	0.005	−0.016	−0.053	0.06
	(0.2)	(3.1)	(−0.1)	(−4.3)	(1.2)	(−0.1)	(−0.3)	1.10
24 Utilities	6.058	−0.017	0.091	−0.074	0.032	0.105	−0.530	0.67
	(1.4)	(−0.2)	(1.3)	(−3.2)	(2.3)	(0.2)	(−1.4)	0.44
25 Finance	16.584	0.098	−0.078	−0.020	0.053	0.777	−1.306	0.78
	(3.6)	(1.7)	(−0.7)	(−0.2)	(3.3)	(2.0)	(−3.4)	0.79
26 Remaining Services incl. Government	5.063	−0.036	−0.003	0.039	0.015	0.004	−0.355	0.16
	(1.8)	(−1.1)	(−0.2)	(1.3)	(1.8)	(0.0)	(−1.7)	0.57

*) w(US,G) = alpha + beta(DM)*ln p(M) + beta(DK)*ln p(K) + beta(DW)*ln p(W) + beta(DT)*time + beta(DD)*D(US) + beta(DQ) * ln Q.
Source: own computations.

Table 12

Estimates for the scale elasticity of costs *) in the bilateral factor demand system of the US and the Federal Republic of Germany by Industry

(1960−1985)

Industry	alpha(Q) (t−value)	beta(QM) (t−value)	beta(QK) (t−value)	beta(QW) (t−value)	beta(QT) (t−value)	beta(QD) (t−value)	beta(QQ) (t−value)	R^2 DW
1 Agriculture								
2 Mining	−12.689	0.062	−0.053	−0.009	0.005	−2.603	1.170	
	(−1.5)	(1.0)	(−0.9)	(−8.2)	(0.5)	(−1.9)	(1.4)	
3 Construction	−4.926	−0.041	0.014	0.027	−0.005	−0.517	0.406	
	(−1.7)	(−0.5)	(0.6)	(0.3)	(−1.3)	(−2.3)	(1.7)	
4 Foods	−3.591	0.064	−0.042	−0.022	−0.005	−0.005	−0.005	
	(−1.1)	(1.0)	(−1.5)	(−0.3)	(−0.6)	(−0.6)	(−0.6)	
5 Textiles	−2.485	−0.066	0.063	0.003	−0.003	−0.113	0.235	
	(−0.7)	(−1.9)	(1.6)	(0.1)	(−0.4)	(−014)	(0.6)	
6 Apparel	−1.453	−0.048	0.046	0.002	0.002	0.048	0.129	
	(−1.2)	0.000	(2.3)	(0.1)	(0.9)	(0.3)	(1.0)	
7 Lumber	1.235	0.102	0.037	−0.139	0.007	0.667	−0.155	
	(1.0)	(3.7)	(1.5)	(−4.3)	(2.5)	(2.9)	(−1.3)	
8 Furniture								
9 Paper	−0.171	0.044	0.003	−0.047	0.001	−0.243	0.004	
	(−0.2)	(1.0)	(0.1)	(−1.1)	(0.4)	(−1.6)	(0.0)	
10 Printing	−0.573	−0.087	−0.060	0.147	−0.003	−0.528	0.053	
	(−0.4)	(−2.8)	(−2.0)	(4.3)	(−0.7)	(−2.2)	(0.4)	
11 Chemicals	−4.274	0.069	−0.014	−0.055	−0.019	−0.248	0.336	
	(−1.7)	(1.2)	(−0.3)	(−1.5)	(−1.3)	(−0.7)	(1.6)	
12 Petroleum	−6.648	0.043	−0.033	−0.010	−0.031	−0.326	0.548	
	(−2.0)	(0.6)	(−0.6)	(−0.4)	(−2.5)	(−0.6)	(1.8)	
13 Rubber	0.103	−0.013	0.015	−0.002	0.001	0.000	−0.023	
	(0.1)	(−0.5)	(0.7)	(−0.1)	(0.1)	(0.0)	(−0.2)	
14 Leather	−2.357	0.003	0.023	−0.026	0.006	−0.062	0.246	
	(−0.3)	(0.1)	(0.4)	(−0.6)	(0.3)	(−0.3)	(0.3)	
15 Stone	−1.245	0.007	0.010	−0.017	−0.005	−0.040	0.099	
	(−0.8)	(0.1)	(0.2)	(−0.4)	(−0.8)	(−0.3)	(0.7)	
16 Primary Metal	−1.384	0.082	0.037	−0.119	−0.005	0.201	0.105	
	(−0.5)	(3.6)	(2.5)	(−4.5)	(−0.8)	(1.0)	(0.4)	
17 Fabricated Metal	−0.841	−0.021	0.068	−0.047	−0.002	0.020	0.055	
	(−0.5)	(−0.4)	(1.3)	(−1.0)	(−0.4)	(0.1)	(0.3)	
18 Machinery	−6.230	0.049	0.034	−0.083	−0.150	−0.018	0.510	
	(−1.6)	(1.6)	(1.0)	(−4.0)	(−1.5)	(−0.2)	(1.6)	
19 Electrical Machinery	−0.101	−0.012	0.019	−0.007	−0.001	−0.072	−0.005	
	(−0.1)	(−0.3)	(0.4)	(−0.3)	(−0.1)	(−0.7)	(−0.0)	
20 Motor Vehicles	2.030	−0.020	−0.013	0.033	0.011	0.050	−0.187	
	(1.5)	(−0.7)	(−0.4)	(1.0)	(2.0)	(0.5)	(−1.6)	
21 Transport Equipment	0.315	0.049	0.012	−0.061	0.003	0.076	−0.055	
	(0.6)	(2.3)	(0.5)	(−2.5)	(1.0)	(0.6)	(−1.0)	
22 Precision Instruments	−2.579	0.030	0.050	−0.080	−0.192	0.236	0.236	
	(−1.2)	(1.3)	(1.2)	(−1.7)	(−0.7)	(1.1)	(1.1)	
23 Miscellaneous Manufacturing	−6.519	0.076	−0.018	−0.058	−0.008	−0.053	0.598	
	(−1'2)	(1.9)	(−0.6)	(−4.7)	(−0.7)	(−0.3)	(1.1)	
24 Utilities	−3.397	−0.027	−0.086	0.113	−0.018	−0.529	0.287	
	(−−0.7)	(−0.3)	(−0.7)	(1.7)	(−0.8)	(−1.4)	(0.7)	
25 Finance	−2.927	−0.166	0.011	0.155	−0.002	−1.306	0.245	
	(−0.6)	(−2.1)	(0.1)	(1.1)	(−0.1)	(−3.4)	(0.6)	
26 Remaining Services incl. Government	−1.849	0.053	−0.151	0.098	−0.005	−0.355	0.122	
	(−0.5)	(0.7)	(−2.6)	(1.1)	(−0.4)	(−1.7)	(0.4)	

*) w(Q) = alpha + beta(QM)*ln p(M) + beta(QK)*ln p(K) + beta(QW)*ln p(W) + beta(QT)*time + beta(QD)*D(US) + beta(QQ) * ln Q.

Source: own computations.