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Transfers and transition: The impact of government support on factor demand and production in Eastern Germany

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**Transfers and Transition: The Impact of Government Support
on Factor Demand and Production in Eastern Germany**

by
Katja Gerling



Institut für Weltwirtschaft an der Universität Kiel
The Kiel Institute of World Economics

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24100 Kiel
Federal Republic of Germany

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Abstract

The paper presents an error-correction model of factor demand and output, analysing the effects of a change in relative factor prices on investment, employment and output in the eastern German manufacturing sector. The principal aim is twofold: first, to examine if the large amounts of capital subsidization mainly benefitted the capital-intensive industries, thus leading to distortions in the production structure, and second, to find out if the subsidies proved to be successful in creating employment in the eastern German industries or if they rather contributed to a substitution of capital for labour and skilled labour. The model uses the concept of the user cost of capital for a representation of capital costs, integrating the main instruments of subsidization. The results confirm that all in all, capital subsidies seem to encourage capital-intensive production structures. As to employment, the positive output effect might overcompensate the substitution effect only for skilled, but not for unskilled labour and only in the capital- and surprisingly also in the labour-intensive industries. For the skilled-labour-intensive industries, the outcome is much less encouraging (E22, E24, H20, C33).

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1. Introduction¹

Seven years after unification, the expectations of "flourishing landscapes" which were promised to eastern Germany with firm conviction by Germany's Chancellor Kohl have been widely weakened by the slowness of the adjustment process. Shares of only 7.5 percent in overall-German industrial production and 3 percent in overall German foreign sales — compared to a share of about 20 percent in overall German population — illustrate the competitive weakness of the eastern German industry, which is particularly severe on international markets.

The eastern German economy was hit by the pressures of competition quasi overnight and not at all well-prepared. The old patterns of specialization inside the COMECON became obsolete with the breakdown of the eastern European export markets. At the same time, the chances of finding new markets in the west were crucially restricted by the conditions of the establishment of the German Economic, Monetary and Social Union (GEMSU) in the summer of 1990. The currency conversion rate of 1:1 was far from being in line with the competitiveness of the eastern German economy. It meant an enormous appreciation of the eastern German currency and thus caused the collapse of the eastern German export industries. It was partly responsible for the devaluation of large parts of the capital stock. In addition to this, the rapid wage increase contributed to the weak competitive position because it did not leave eastern German firms any possibility to compensate their backwardness in technology, product design and sales services by pursuing a low-cost strategy and by "pricing themselves into international markets".

¹ Thanks to Prof. Dr. Gerd Hansen, Axel Schimmelpfennig and Klaus-Dieter Schmidt for helpful comments on earlier versions.

Against this background, it is obvious that eastern German firms had no chance to survive on their own. Thus, in order to help them through their struggle for competitiveness on national and on international markets and in order to alleviate the frictions of the painful transformation process, the German government had to provide large sums of financial means. In this context, it pursued a strategy of massively supporting investment which was considered as the most promising strategy to quickly restructure the eastern German industrial base and to foster long-term growth and employment. Like this, potential investors were supposed to be compensated for locational disadvantages and lacking positive externalities. All in all, between 1990 and 1996, more than DM 50 billion were given to eastern German firms as government grants, more than DM 80 billion as loans by government banking institutions, roughly DM 40 billion were granted in the form of tax reductions through extra depreciation allowances. The lion's share, more than DM 160 billion, were given by the Treuhandanstalt for restructuring enterprises, clearing debts, financing employment programs and the like (Boss and Rosenschon 1996).

However, government intervention of such a kind and scale might lead to allocative distortions in the economy, i.e. to deviations from an optimal factor allocation. It enters the decision functions of economic agents and alters the economic structure through changes in relative prices. As such, it may lead to strong substitution processes which negatively affect the labour market, thus missing the aim of creating extra jobs. Moreover, it influences the sectoral structure of the economy in a selective way: Changes in relative factor prices caused by large sums of investment subsidies can be expected to benefit in particular capital-intensive branches. Thus, it is possible that the extensive support led to an industrial structure in the eastern German economy which is

not in accordance with its factor endowment. To analyse this is the purpose of this paper.

The structure of the remaining part is as follows: Section 2 examines the different effects that capital subsidies have on production and factor demand and gives some rough evidence on production and factor demand in different sectors of eastern German manufacturing. Section 3 derives a theoretical model which is able to analyse output and substitution effects of a change in relative factor prices. Section 4 gives the estimation of the model and an interpretation of its results. Section 5 concludes.

2. Effects of Capital Subsidization on Eastern German Manufacturing: An Overview

In order to rebuild the eastern German industrial base, the Federal government launched numerous programs to support capital investment by reducing capital costs. The support towards the factor capital was deliberately chosen because the lack of a modern capital stock was seen as the most important obstacle for economic growth and competitiveness in eastern Germany. The strategy of subsidizing labour instead, which was suggested mainly by Anglo-American economists (Akerlof et al. 1991; Begg and Portes 1992; Hallet, Ma and Mélitz 1994), was rejected because of the danger of conserving uncompetitive labour-intensive production structures and of encouraging trade unions to enhance their wage claims.

The principal instruments of subsidization in eastern Germany are:

- the investment bonus (Investitionszulage), which firms are legally entitled to and which is not subject to taxation,

- the investment grant for the improvement of regional economic structures (Gemeinschaftsaufgabe "Verbesserung der regionalen Wirtschaftsstruktur") — in terms of subsidy equivalent the most important support program,
- extra depreciation allowances and
- subsidized loans, which are granted by the government banking institutions, the DtA (Deutsche Ausgleichsbank) and the KfW (Kreditanstalt für Wiederaufbau) and which are mainly directed towards small- and medium-sized enterprises (SMEs).

Table 1 – Subsidies to Eastern German Firms, 1990-1996 (Billion DM)

	1990	1991	1992	1993	1994	1995	1996	Total
Bonus	0.00	1.04	4.18	4.89	4.44	3.64	2.49	20.68
Grant	0.10	7.09	5.15	5.41	5.64	4.40	6.41	34.20
Depr. allowance ^a	0.00	3.36	4.90	6.26	7.06	8.83	9.42	39.83
KfW-loans	2.48	10.42	8.04	6.28	6.69	4.29	4.94	43.14
DtA-loans	3.03	8.22	8.42	7.46	5.97	4.28	3.06	40.44

^aEstimated tax reduction.

Source: Dietrich, Ragnitz, Rothfels et al. (1998).

The figures on the financial means granted to eastern German firms according to these instruments can be taken from Table 1.²

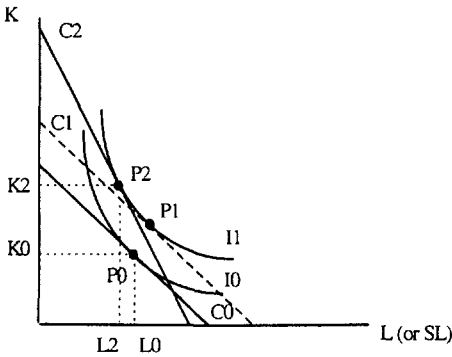
² It has to be noted that the analysis is confined to the Federal Government support programs. The numerous support programs which were set up by the eastern German Länder and communes are not taken into account here. The same thing applies to the subsidies given by the Treuhandanstalt; these have to be neglected due to a lack of detailed data.

Generally speaking, capital subsidies as granted to eastern German firms have two effects which influence the allocation of factors:

- An output effect: Capital subsidies — as other subsidies — lower overall production costs and thus give an incentive to firms to invest. The cost reduction is strongest in those industries which use the subsidized factor — here: fixed capital — intensively.
- A substitution effect: Capital subsidies lower the price of the factor capital relative to other factor prices. Thus, they give an incentive to firms to substitute relatively cheap capital for relatively expensive factors of production, e.g. labour and skilled labour. However, this mechanism only works if factors are assumed to be at least partly substitutable.

In Figure 1, P_0 represents the optimal combination of the production factors fixed capital (K) and labour (L) — or alternatively skilled labour (SL) — for a given ratio of factor prices and a given output level I_0 . The output effect now causes an outwards shift of the isocost line from C_0 towards C_1 . Output reaches a higher level (I_1) and the use of both factors increases. The firm faces a new optimal combination of factors represented by P_1 . The substitution effect causes at the same time a turn of the isocost line from C_1 to C_2 . Capital becomes relatively cheaper and is substituted for labour. The optimal combination of factors is shifted to P_2 . Whereas the use of capital is increased by both effects, the final outcome for labour is ambiguous. While the substitution effect decreases the employment of labour in the production process, the output effect increases it. Without any further assumptions, it is not possible to say which effect will predominate.

Figure 1 – Output and Substitution Effect of a Change in Relative Factor Prices



If one subdivides manufacturing into three sectors, a capital-intensive one, a skilled-labour-intensive one and a labour-intensive one, constituting a kind of "mini Heckscher-Ohlin economy" (Corden 1982), one can formulate some hypotheses as to the effects of capital subsidization on different industries: Capital subsidization, leading to a fall in the relative price of the factor capital, can be expected to be most beneficial for the capital-intensive manufacturing sector because the capital cost reduction has the largest effect here. Thus, the large positive output effect initiated by the subsidies can be expected to compensate or even overcompensate the substitution effect in this sector and lead to a positive capacity and employment effect, whereas in the labour- and skilled-labour-intensive industries, the output effect of the capital subsidization is not as strong so that the substitution effect might prevail concerning employment.

This hypothesis is somewhat manifested in the actual figures on investment and employment according to factor intensities. The former show clearly that investment in eastern Germany is biased towards capital-intensive industries

whose share was much larger between 1991 and 1996 than the share of these industries in western German investment as frame of reference (Table 2).

Table 2 – Structure of investment in the manufacturing sector in Germany according to factor intensities of industries (percent)^a

Sectors	Eastern Germany 1991–1996 ^b	Western Germany 1991–1996 ^b
Labour-intensive	15	22
Skilled-labour-intensive	23	38
Capital-intensive	62	40

^aEnterprises with 20 and more employees. – ^bCumulated gross fixed capital.

Source: ifo; own calculations.

Table 3 – Shares in Employment in the Eastern German Manufacturing Sector According to Factor Intensities^a

Sectors	1991	1996
Labour-intensive	24	32
Skilled-labour-intensive	40	30
Capital-intensive	36	38

^aEnterprises with 20 and more employees.

Source: German Federal Statistical Office; own calculations.

The latter confirm a particularly problematic situation for the skilled-labour-intensive branches whose share in employment decreased heavily between 1991 and 1996 as compared to other industries (Table 3).

The shares of output according to factor intensities confirm the decline of the skilled-labour-intensive industries by a fall in net output share of more than an eighth between 1991 and 1996 as opposed to a rather surprising rise in the share of labour-intensive industries, possibly enhanced by the post-reunification boom of construction and local demand (Table 4). All in all, this leads to the supposition that capital subsidization did not at all prevent the establishment of industry structures which do not seem to be in line with the potential com-

parative advantages of a rather high-skill-high-wage region such as eastern Germany.

Table 4 – Shares in net output in the eastern German manufacturing sector according to factor intensities, 1991–1996 (percent)^a

Sectors	1991	1996
Labour-intensive	20	26
Skilled-labour-intensive	37	32
Capital-intensive	43	42

^aEnterprises with 20 and more employees.

Source: German Federal Statistical Office; own calculations.

It cannot be said beforehand what is the net outcome of the effects in all industries taken together on the labour market. It can be expected that the net effect leads to a shedding of labour and skilled labour mainly in the labour and skilled-labour-intensive sectors whereas in the capital-intensive sector, the substitution effect might or might not be compensated by the positive output effect. If one considers the rapid wage increases accompanying the process of eastern German transformation and the general downward inflexibility of wages, it is not surprising that so far, more labour and skilled labour have been shed than have been absorbed anywhere else. This is impressively mirrored in the development of employment in eastern German manufacturing (Table 5).

Table 5 – Employed persons in the eastern German manufacturing sector, 1991–1996 (in 1000)^a

	1991	1992	1993	1994	1995	1996
Employed persons	1,638	836	685	634	580	559

^aEnterprises with 20 and more employees.

Source: German Federal Statistical Office.

Such an outcome would strongly contradict one of the essential aims of capital subsidization as stated by the German government in its guidelines for the most

important subsidy — the investment grant for the improvement of regional economic structures (Rahmenplan der Gemeinschaftsaufgabe "Verbesserung der regionalen Wirtschaftsstruktur"): creating and sustaining employment.

3. Factor Demand and Output: A Theoretical Model

3.1 Factor Demand

The model to test the outcome of output and substitution effects of changes in the factor price relations in different industries borrows heavily from models by Faini and Schiantarelli (1985), Asmacher, Schalk and Thoss (1987), Deitmer (1993) and Franz and Schalk (1996). It uses a simple production function of the Cobb-Douglas type which includes three factors of production, namely labour, skilled labour and capital (L , SL , K) and an efficiency parameter A .

$$(3.1) \quad Q_{jt} = A_{jt} e^{\lambda t} L_{jt}^{\alpha} SL_{jt}^{\beta} K_{jt}^{\gamma}$$

with: j = industry index

t = time index

From this production function, it is possible to derive a firm's factor demand equations under two different behavioural assumptions: First, it can be assumed that firms maximize their profits. The maximization conditions derived from the profit equation

$$(3.2) \quad G_{jt} = pQ_{jt} - wL_{jt} - wslSL_{jt} - cK_{jt}$$

where p denotes the price level, wl the cost of labour, wsl the cost of skilled labour and c the cost of capital, are:

$$(3.3) \quad \frac{\partial Q}{\partial L} = \frac{wl}{p}$$

$$(3.4) \quad \frac{\partial Q}{\partial SL} = \frac{wsl}{p}$$

$$(3.5) \quad \frac{\partial Q}{\partial K} = \frac{c}{p},$$

expressing that the marginal products of all factors of production equal their real factor prices.

Output in this kind of modelling is the potential output of the firm, always creating its own demand, so that the underlying assumption is perfect markets and the absence of under-utilized capacities. Moreover, the model only works with decreasing returns to scale.³

Second, in order to avoid the restrictions on market conditions and on returns to scale, it can be assumed that firms minimize their costs. The minimization conditions derived from the cost equation

$$(3.6) \quad C_{\mu} = wL_{\mu} + wslSL_{\mu} + cK_{\mu}$$

are:

$$(3.7) \quad \frac{\partial Q / \partial L}{\partial Q / \partial SL} = \frac{wl}{wsl}$$

$$(3.8) \quad \frac{\partial Q / \partial L}{\partial Q / \partial K} = \frac{wl}{c}$$

$$(3.9) \quad \frac{\partial Q / \partial SL}{\partial Q / \partial K} = \frac{wsl}{c},$$

yielding the following factor demand functions:

³ The factor demand functions have a negative slope only for decreasing returns to scale. For increasing returns to scale, they would be positively sloped, for constant returns to scale, the factor demand system cannot be solved (Asmacher, Schalk and Thoss 1987).

$$(3.10) \quad L_{jt} = A_{jt}^{-\varepsilon} e^{-\lambda t \varepsilon} \left(\frac{\alpha}{\beta} \frac{wl}{wsl} \right)_{jt}^{-\beta \varepsilon} \left(\frac{\alpha}{\gamma} \frac{wl}{c} \right)_{jt}^{-\gamma \varepsilon} Q_{jt}^{\varepsilon}$$

$$(3.11) \quad SL_{jt} = A_{jt}^{-\varepsilon} e^{-\lambda t \varepsilon} \left(\frac{\alpha}{\beta} \frac{wl}{wsl} \right)_{jt}^{\alpha \varepsilon} \left(\frac{\beta}{\gamma} \frac{wsl}{c} \right)_{jt}^{-\gamma \varepsilon} Q_{jt}^{\varepsilon}$$

$$(3.12) \quad K_{jt} = A_{jt}^{-\varepsilon} e^{-\lambda t \varepsilon} \left(\frac{\alpha}{\gamma} \frac{wl}{c} \right)_{jt}^{\alpha \varepsilon} \left(\frac{\beta}{\gamma} \frac{wsl}{c} \right)_{jt}^{\beta \varepsilon} Q_{jt}^{\varepsilon}$$

with:
$$\varepsilon = \frac{1}{\alpha + \beta + \gamma}$$

Because both relative factor prices and output appear as explanatory variables in the factor demand functions, this kind of modelling allows to properly separate the substitution effect from the output effect. Output in this case is the actual, not the potential output as under the assumption of profit maximization. This allows to consider supply as well as demand side effects which might manifest themselves e.g. in under-utilized capacities. Restrictive assumptions concerning returns to scale are not necessary (Asmacher, Schalk and Thoss 1987). For these reasons, a model based on cost minimization behaviour seems to be more suitable for the following analysis.

However, even under the assumption of cost minimization, the derived factor demand functions model economic reality only poorly since they are based on a Cobb-Douglas technology which hypothesizes — among other things — perfect substitutability of factors at all times. In order to modify this substitutability, many authors have suggested and empirically tested a putty-clay-approach to production technology (e.g. Bischoff 1971; King 1972; Faini and Schiantarelli 1985; Artus and Muet 1990). A putty-clay technology implies that a firm can only choose the factor relations on newly installed equipment, not on old capital vintages, i.e. factors of production are substitutable only ex ante, not ex post.

For the cost minimization conditions then follows from the ex-ante production function:

$$\frac{I_t}{\Delta L_t} = f\left(\frac{wl_t}{c_t}\right), \quad \text{resp.} \quad \frac{I_t}{\Delta SL_t} = f\left(\frac{wsl_t}{c_t}\right),$$

implying that changes in factor demand, i.e. changes in the demand for labour, in the demand for skilled labour and in the demand for capital — the latter signified by the variable investment (I) — depend on the level of relative factor prices. Production coefficients in the ex-post production function remain fixed.

The cost minimization conditions yield the following factor demand functions for the putty-clay model:

$$(3.13) \quad \Delta L_\mu = \Delta L((wl/c)_\mu, (wsl/wsl)_\mu, TE_\mu, \Delta Q_\mu)$$

$$\text{with:} \quad \Delta L_\mu = L_\mu - (1 - d_L)L_{\mu,t-1} \quad \Leftrightarrow \quad L_\mu = (1 - d_L)L_{\mu,t-1} + \Delta L_\mu$$

$$(3.14) \quad \Delta SL_\mu = \Delta SL((wsl/c)_\mu, (wsl/wsl)_\mu, TE_\mu, \Delta Q_\mu)$$

$$\text{with:} \quad \Delta SL_\mu = SL_\mu - (1 - d_{SL})SL_{\mu,t-1} \quad \Leftrightarrow \quad SL_\mu = (1 - d_{SL})SL_{\mu,t-1} + \Delta SL_\mu$$

$$(3.15) \quad I_\mu = I((wl/c)_\mu, (wsl/c)_\mu, TE_\mu, \Delta Q_\mu),$$

where d_L , resp. d_{SL} , represents the share of workers having worked on scrapped machines and TE stands for technical efficiency.

3.2 The Concept of the User Cost of Capital

In order to model the cost of the factor capital in eastern Germany, the concept of the user cost of capital, which is based on Jorgenson (1963), is chosen. It reduces dynamic intertemporal optimization to static optimization and allows to

integrate the various capital subsidies granted by the government to eastern German firms relatively easily (Deitmer 1993). The user cost of capital can be derived from the maximization of the sum of discounted future cash flows of the firm:

$$(3.16) \quad V = \sum_{t=1}^{\infty} [p_t Q_t - wL_t - wsISL_t - q_t(K_{t+1} - K_t + \delta K_t)] [1 + i(1 - u)]^{-t} \rightarrow \max!$$

The maximization condition postulates the marginal product of capital (f'_k) to look as follows:

$$(3.17) \quad f'_k = \left[i_t(1 - u_t) + \delta_t - \frac{q_{t+1} - q_t}{q_t} \right] q_t$$

with the term in brackets representing the user cost of capital (c). In the equation, i represents the interest rate, u the tax rate, δ the depreciation rate and q the price index of investment goods.⁴

One crucial factor influencing eastern German firms' user cost of capital — which is supposed to be at the core of the analysis — is not yet considered: the instruments of capital subsidization. Basically, there are two possibilities of how to integrate them into the user cost concept: either as subsidy equivalent of the absolute figures of subsidies granted to firms as can be obtained from the German subsidy statistics, or as grant and credit rates available to firms, expressed in subsidy equivalents. Since the absolute figures are to a large extent dependent on actual investment of firms in eastern Germany, the first method is highly problematic for an analysis of factor demand — one would basically end

⁴ In the following analysis, it is assumed that q_{t+1} equals q_t , i.e. that $\frac{q_{t+1} - q_t}{q_t} = 0$, which is a steady-state-assumption, but — considering the data on investment goods prices in eastern Germany — not too unrealistic.

up regressing investment figures on investment figures (Asmacher, Schalk and Thoss 1987). For this reason, the second method is chosen. The following capital subsidies are considered in this context:

(a) Investment bonus

The investment bonus is available only for equipment investment. Its rates in eastern Germany moved down from 12 percent of the investment made between 1991 and June 1992 to 8 percent between July 1992 and June 1994 and finally to 5 percent up to 1996. There were special rates for small and medium-sized enterprises (SMEs) (10 percent from July 1992 onwards) and for enterprises owned by eastern German citizens (20 percent in 1993 and 1994).⁵ The investment bonus is not subject to taxation; its rates are to full extent subsidy equivalent.

(b) Investment grant

The investment grant is available for equipment investment as well as for buildings. From 1991 to 1994, the rates granted in eastern Germany varied according to the type of investment, i.e. 23 percent for establishment, 20 percent for expansion and 15 percent for rationalization and modernization of a firm.⁶

⁵ For calculation, the shares of equipment investment, investment of SMEs in eastern Germany and investment of enterprises owned by eastern Germans are taken from Köddermann (1996). Because of a lack of data, the shares of equipment investment for 1993 are taken as representative for all years and the shares of SME investment and investment of eastern German-owned firms for 1993 are taken as representative for the years from 1994 onwards. Since the greatest changes in the structure of firm size and ownership occurred in the first years after reunification, it seems legitimate to proceed in this way.

⁶ The shares of subsidized establishment, expansion and rationalization/modernization investment in each industry were calculated from the statistics of the Bundesamt für Wirtschaft (1997).

In 1995 and 1996, rates varied according to firm size, i.e. 35 percent for firms with more and 50 percent for firms with fewer than 500 employees. Cumulation with other subsidy instruments is possible. The investment grant rates are — like the bonus — to full extent subsidy equivalent. They are, however, subject to taxation which shall be considered in the model via lowered depreciation allowances (see section 4.1).

(c) Depreciation allowance

Besides the normal depreciation practice which is assumed to be degressive with a rate of 30 percent on equipment over 10 years and linear on buildings over 25 years, firms in eastern Germany have access to an extra depreciation allowance of 50 percent in the first year combined with a complete linear depreciation in the first five years. The subsidy equivalent of this extra allowance consists of the discounted tax advantage. Thus, the depreciation allowance only benefits firms which actually make profits.

(d) Subsidized loans

After reunification, the German government banking institutions launched several credit programs in order to support small and medium-sized eastern German firms by granting them loans at reduced interest rates. Conditions vary greatly over programs.⁷ It is possible for firms to cumulate these subsidized loans with the investment grant and bonus.⁸

⁷ For a detailed listing of programs and conditions see appendix, Table A1.

⁸ For SMEs, the sum of cumulated subsidies can amount to up to 85 percent of total investment. It is assumed however, that cumulation is only possible between 1991 and 1994.

Including all the above mentioned capital subsidies into the user cost of capital yields the following expression:

$$(3.18) \quad c_{\mu} = \frac{1 - z1_{\mu} - z2_{\mu} - Kred_{\mu} - (1 - z2_{\mu})uSAfA_{\mu}}{1 - u} \left[i(1 - u) + \delta_{\mu} - \frac{q_{t+1} - q_t}{q_t} \right] q_{\mu}$$

with: $z1$ = rate of investment bonus

$z2$ = rate of investment grant

$Kred$ = subsidy equivalent of subsidized loans by KfW and DtA

$SAfA$ = subsidy equivalent of depreciation allowance

This expression, however, is only valid for firms which are actually making profits. For those operating with losses, neither tax rates nor rates of depreciation allowances influence their user cost of capital in any way, so that the equation has to be slightly modified into:

$$(3.19) \quad c'_{\mu} = (1 - z1_{\mu} - z2_{\mu} - Kred_{\mu}) \left(i + \delta_{\mu} - \frac{q_{t+1} - q_t}{q_t} \right) q_{\mu}$$

Since there is a large share of eastern German firms still operating in the red — in 1991 it was more than 80 percent, in 1996 still around 60 percent — the modification cannot be ignored. Thus, the two expressions for the user cost of capital enter the model weighted with the share of eastern German firms making profits, resp. those making losses. These shares are taken from a firm survey made by the DIW, which started in summer 1991 and by now includes between

25 and 30 percent of manufacturing in terms of employees, and own estimations.⁹

All in all, the government instruments of capital subsidization decreased capital costs in eastern Germany by 21 up to 35 percent depending on the year and the industry. The exact figures of the user cost of capital with and without subsidies are given in the appendix.

3.3 *Modelling Output*

In a factor demand model assuming cost minimization, the output variable is exogenous but not constant. Next to the factor price relations, it is the crucial variable determining firms' factor demand decisions. Whereas the factor price relations describe the substitution effect, the output variable makes it possible to model an output effect of a change in relative factor prices. In order to do this, however, it is necessary to construct an output equation representing a connection between factor prices and industry output. The relevant variable for such an output equation is — in a putty-clay model — the additional output on newly installed equipment in period t , which is calculated as total output after installation minus total output before installation plus output on scrapped machines:

$$(3.20) \quad \Delta Q_{jt} = Q_{jt} - (1 - d_Q)Q_{j,t-1}$$

with: d_Q = scrapping rate

⁹ Although the shares vary across industries, they had to be assumed to be equal because data available on the industry-level was not sufficient. The shares are reported in the appendix (Table A2).

Since the output variable considered in this model represents the actual, not the potential output, it is possible to include supply as well as demand side aspects as determinants of a firm's output decision.

On the supply side, the most important factors influencing industrial output in eastern Germany seem to be cost conditions, i.e. factor costs.

On the supply as well as on the demand side, a specific aspect of the eastern German unification process seems to be of particular relevance for industrial output decisions, namely the development of market conditions for tradable, here: industrial and non-tradable, here: non-industrial goods. Economic unification by the establishment of the GEMSU altered the structure of relative prices and of production between tradeables (T) and non-tradeables (NT) in three ways:

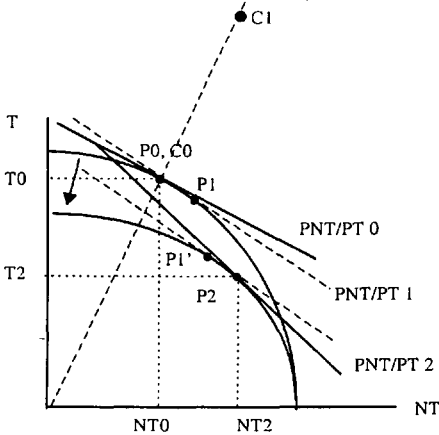
- First, the opening of the eastern German economy to world markets confronted producers of tradeables with world market prices. As usual in a socialist economy, the price structure in the former GDR was heavily distorted in favour of tradable goods so that — under the assumption of eastern Germany being a small economy — prices of tradable goods fell relative to those of non-tradable goods, the latter being sheltered from world market influences and largely determined by local demand and cost conditions. Looking at the diagram (Figure 2), the price relation thus turned from the initial relation $P_{NT}/P_T 0$, which is tangential to the transformation curve in the initial production and consumption point P_0 , resp. C_0 , to $P_{NT}/P_T 1$.
- Second, the currency conversion rate of 1:1 together with rapidly increasing eastern German wages pushed marginal cost of labour as well as of capital above their marginal revenues so that large parts of the

production factors became economically obsolete. Production possibilities shrank predominantly in the tradeables sector because this sector was hit most by cost pressure and price competition. In the model, this is visualized by a recession of the transformation curve with a bias towards the tradeables sector.

- Third, the massive consumptive transfer payments led to an increasing demand for tradable as well as for non-tradable goods so that the consumption point moved to $C1$.¹⁰ Excess demand for non-tradeables caused relative prices in this sector to rise even further, whereas the price of tradeables, which is assumed to be determined by world market prices, remained unchanged ($PNT/PT 2$). Resources moved from tradeables to non-tradeables and led to increasing production of the latter ($P2$). Since the excess demand of tradeables could only be met by higher imports, the trade balance ran into deficit, which is represented by the vertical distance between $P2$ and $C1$.

¹⁰ It is likely that the fall in relative prices of tradeables also changed the preferences of eastern German consumers towards this sector which could be shown by an upwards turn of the Engel curve. For simplification of the model, this effect is neglected here.

Figure 2 – Changes of relative prices and structural change in the eastern German economy through the establishment of the GEMSU



It is obvious that all these conditions of German unification worked in the same direction: towards an increase in production and attraction of resources in the non-tradeables sector which can roughly be interpreted as the non-industrial sector. Because this effect can be mainly put down to changes in relative goods prices, the variable which is chosen to picture this kind of Dutch-disease scenario in the model is the ratio of prices of tradable and non-tradable goods.¹¹

Considering the above mentioned aspects, an adequate output equation can be formulated as follows:

¹¹ It has to be noted here that for reasons of data congruence the price index for non-tradeables (P_{NT}) is not calculated from the non-industrial sector (e.g. services, construction and the like), but from a weighted average of producer price indices of industrial goods whose trade share is below average. For a classification of industries according to trade shares see in this context Klodt, Stehn et al. (1994).

$$(3.21) \quad \Delta Q_{jt} = \Delta Q \left(\begin{array}{ccccccc} w_{lreal_{jt}} & w_{slreal_{jt}} & c_{real_{jt}} & TE_{jt} & \frac{P_T}{P_{NT_{jt}}} & Q_{j,t-1} & \end{array} \right)$$

- - - + + -

where *wlreal*, *wslreal* and *creal* are the real factor costs and P_T / P_{NT} is the relative price between tradable and non-tradable goods. The direction in which these variables are expected to influence industrial output is expressed in the plus and minus signs.

4. Estimation and Results

4.1 The Data

The data situation on the eastern German industry-level is clearly far from being satisfactory for estimating a model as described in the previous section. The time series are short and not at all complete. For the model, sometimes western German data had to be taken in order to fill the gaps, sometimes non-available time-series data had to be put down to a representative year.

The principal data base is the production statistics of the German Federal Statistical Office which comprise firms with more than 20 employees. The chosen period ranges from 1991 to 1996 and relies on yearly data for two-digit industries. A serious constraint in the data base is the change of the industry classification from the "SYPRO" (system of industries for the statistics of the producing sector from 1979) to the NACE Rev. 1 (statistical system of industries in the European Community) in 1995. Because re-calculations of statistics according to the new classification do not exist for the years before 1995, it was necessary to re-classify industries from the NACE back to the SYPRO classification for the years 1995 and 1996. This was done according to

a classification key from the Federal Statistical Office on the four-digit level in order to get a homogeneous time series. Exact assignments of NACE industries were still not possible in all cases, though, so that the re-classification achieved is only rough — especially in cases where data on the four-digit industry level were not available at all. However, the figures do not indicate a structural break for 1995 and 1996 which makes this way of adjusting the data seem legitimate.

The differentiation between labour and skilled labour is made according to wage classes which can be taken from the wage structure statistics. The number of workers is weighted with the share of workers in the lowest of three wage classes and the number of employees with the share of employees in the lowest two of five salary classes in order to get the number of employed persons belonging to "labour". The residual — i.e. workers and employees in higher wage classes who need some qualification for their work — are then classified as "skilled labour". Wages and salaries for labour and skilled labour are calculated in a similar way from the gross monthly salaries of employees and the gross weekly wages of workers according to wage classes.

The figures on investment in eastern Germany are taken from the ifo Investitionstest by the ifo Institute in Munich. The Investitionstest is based on a firm survey which comprises firms with more than 20 employees (in contrast to the ifo Investorenrechnung which includes all firms); its results, however, are not necessarily compatible with aggregated investment figures reported by the Statistical Office.

In order to get real output data for eastern German industries, net output was taken for 1991 and the figures for the years to follow were calculated using the output index which is in real terms. Price level data always relies on the index of producer prices.

Because the user cost of capital are not reported for eastern Germany, they had to be calculated from their different components as described in section 3.3. As interest rate, the return on fixed-yield securities was chosen which can be taken from the statistics of the Deutsche Bundesbank. For reasons of simplification, the average tax rate was calculated in a very rough way, only considering the German corporation tax and the Gewerbeertragsteuer, a tax levied by the communes.¹² Wealth tax and the Solidaritätszuschlag (solidarity surcharge for eastern Germany)¹³ were as well neglected as the difference between corporation and income tax. The total rate amounts to 60 percent for 1991 to 1993 and 54 percent from 1994 onwards.¹⁴ The depreciation rate is assumed to be the same over industries due to a lack of industry level data. It can be roughly estimated as 2.6 percent between 1991 and 1996. The investment goods price index was calculated from western German nominal and real investment figures for all firms because eastern German figures are not available on the industry level. Eastern German shares of investment in equipment and buildings, whose price indices can be expected to develop differently, were taken into account, though.¹⁵ Due to data constraints, the index could only be calculated up to 1994. However, since the price index tends to become more and more stable over the years, it is assumed that it roughly stayed the same from 1994 onwards. For this

¹² The Gewerbeertragsteuer is a tax on a firm's earnings. Its level is fixed by the communes so that it varies locally. A second communal tax, the Gewerkekapitalsteuer, a tax on a firm's rateable value, is only levied in western, not in eastern Germany.

¹³ The Solidaritätszuschlag was introduced in Germany in 1993 as a tax surcharge in order to help financing the German reunification. It is levied in eastern as well as in western Germany and is 7.5 percent on income, resp. corporation tax.

¹⁴ For a detailed calculation see Lichtblau (1994).

¹⁵ 1993 was chosen as the representative year for these shares. Data is taken from Köddermann (1996).

reason, the investment inflation rate $\frac{q_{t+1} - q_t}{q_t}$ was neglected in the user cost calculation.

The different components of capital subsidization which lower the user cost of capital shall now be considered in detail:

(a) Investment bonus and investment grant

Because the investment bonus and the investment grant are to full extent subsidy-equivalent, their actual rates can be used in the user cost equation. It has to be taken into account, though, that the investment grant is subject to taxation. Taxation can be integrated into the model directly or indirectly via a deduction of the investment grant rate from allowable depreciation so that taxable profits are increased (Asmacher, Schalk and Thoss 1987; Franz and Schalk 1996). Here it is assumed that firms choose the second alternative because it allows them to spread taxes over several years and to realize interest and liquidity advantages (Deitmer 1993). Thus, the rate of the investment grant appears in the user cost equation not only as a subsidy but also as a deduction from depreciation allowances (see section 3.2).

(b) Depreciation allowance

The subsidy equivalent of the depreciation allowance consists of the discounted tax advantage, i.e. the interest advantage that firms have because their taxable profits are decreased more strongly in the short run as compared to the normal depreciation allowance so that tax payments are partly delayed. The subsidy equivalent is thus calculated as follows:

$$(4.1) \quad uSAfA = e \sum_{i=1}^{10} \frac{u(d1-d0)}{1+i(1-u)^i} + b \sum_{i=1}^{25} \frac{u(d1-d0)}{1+i(1-u)^i}$$

with: e = share of equipment investment
 b = share of buildings
 $d0$ = normal depreciation allowance
 $d1$ = extra depreciation allowance

(c) Subsidized loans

The subsidy equivalent of the subsidized loans by the government banking institutions consists of the discounted interest rate differential between the rate of the loan and market interest rates. It is calculated as follows:

$$(4.2) \quad S = \sum_{t=1}^n K_0 \left(1 - \frac{t-1}{n} \right) \Delta i_0 (1+j)^{-t}$$

with: K_0 = credit
 n = life of credit
 Δi = interest rate differential
 j = discount rate (here: 10 percent)

4.2 *The Basic Empirical Model*

For the estimation of the model, the branches of the industrial sector in eastern German were grouped according to factor intensities in order to find out whether government support and changes in relative factor prices had different effects in industries with different factor intensities. The classification is based on a method used by Fels and Schmidt (1981) and Schmidt and Gundlach (1988) who calculate fixed capital intensity as the gross capital stock per employed person and skilled-labour intensity as discounted wages and salaries

for workers and employees in higher wage categories per employed person. Western German data for 1994 are used for the calculations because it can be expected that eastern German factor intensities are still somewhat distorted so that they would not be suitable as a frame of reference.

Table 6 – Factor Intensities of Manufacturing Industries

SYPRO No.	Industry	Fixed capital intensity ^a (1000 DM)	Skilled-labour intensity ^b (1000 DM)	Classification ^c
22	Refinery	1153.7	393.5	K
25	Quarrying	297.8	142.8	K
27	Iron and steel	451.7	128.8	K
28	Non-ferrous metals	357.2	169.3	K
29	Foundries	225.1	104.9	K
30	Rolling mills etc.	157.1	76.2	L
31	Constructional steel	104.7	157.4	L
32	Machinery	145.0	217.0	SL
33	Road vehicle building	238.8	208.5	SL
34	Shipbuilding	211.0	224.8	SL
35	Aircraft building	156.7	..	SL ^d
36	Electrical engineering	157.7	210.9	SL
37	Mechanics, optical instruments	102.0	154.4	L
38	Metal products	156.3	109.8	L
39	Musical instruments, toys etc.	190.2	83.0	L
40	Chemicals	341.8	244.9	K
52	Glass	278.2	97.7	K
53	Wood	286.9	125.4	K
50	Office machinery	413.5	..	SL ^d
51	Pottery	147.1	65.9	L
54	Wood processing	106.6	89.4	L
55	Paper and pulp	602.3	129.9	K
56	Paper processing	205.3	122.1	L
57	Printing	168.9	108.2	L
58	Plastics	168.0	111.8	L
59	Rubber	196.2	142.5	L
61	Leather	237.6	96.8	K
62	Leather processing	..	64.6	K
63	Textiles	290.2	87.5	K
64	Clothing	98.5	12.2	L
68, 69	Food, tobacco	245.3	72.6	K
	Note: Total manufacturing	209.3	169.9	

^aGross capital stock per employed person 1994, western Germany (in constant prices of 1991). – ^bSkilled labour per employee 1994, western Germany; calculated according to the following equation: $SL/E = (WS/E - w \cdot h \cdot 52) / i_{SL}$ with SL: skilled labour, E: employees 1994, WS: wages and salaries, w: hourly wage of workers in lowest wage category, h: paid weekly hours of workers in lowest wage category, i_{SL} : estimated interest rate on skilled labour (10 percent). – ^cSL: skilled-labour-intensive; K: fixed capital-intensive; L: labour-intensive. – ^dNo data available for 1994. According to previous estimations classified as skilled-labour-intensive.

Source: German Federal Statistical Office; own calculations.

The results of the classification can be seen in Table 6 where industries with a fixed capital intensity above the average of all industries were grouped as capital intensive, industries with a skilled-labour-intensity above the average of all industries as skilled-labour-intensive and all other industries as labour-intensive. For estimation, the relevant time series are then pooled across industries whereby three different pools exist, namely one for capital-intensive, one for labour-intensive and one for skilled-labour-intensive industries. Pooling the data in such a way allows on the one hand to achieve a reasonable number of observations which would not be possible for eastern Germany using only time-series data. On the other hand, however, it involves several important methodical issues which will be discussed in detail in the further analysis.

It has to be noted in this context that due to the small size of the panel of skilled-labour-intensive industries, constructional steel and mechanics/optical instruments, which show the highest skilled-labour intensity of all labour-intensive branches, were — unlike the classification given in Table 6 — grouped as skilled-labour-intensive for the estimation of the model.

If we assume that factor demand and output are not in equilibrium in each period but only in the long run because the variables are subject to an adjustment process caused by adjustment costs, it is reasonable to estimate the model as an adjustment model. The following function of adjustment costs is considered:

$$(4.3) \quad C_t = \alpha_0 + \alpha_1 (y_t^* - y_t)^2 + \alpha_2 (y_t - y_{t-1})^2$$

where y_t^* represents the long-run equilibrium value of y_t and α_i is an adjustment parameter.

From this, we can derive the partial adjustment model as:

$$(4.4) \quad y_t - y_{t-1} = \lambda(y_t^* - y_{t-1});$$

$$\text{with:} \quad \lambda = \frac{\alpha_1}{\alpha_1 + \alpha_2}$$

Generalization of the lag distribution leads to the general adjustment model:

$$(4.5) \quad B(L)y_t = A(L)x_t + u_t$$

$$\text{with:} \quad Lx_t := x_{t-1}$$

Such a lag model can be transformed into an error-correction form so that — if we assume factor demand and output to be log linear — we arrive at the following equations which are used as a basis for estimation (for reasons of simplification, industry-subscripts are left out). Due to the short time period under observation, the maximum lag length chosen here is 2.

$$(4.6) \quad \Delta \ln I_t = \pi_{01} + \sum_{i=0}^2 \rho_{11,i} \Delta \ln Q_{t-i} + \sum_{i=0}^2 \rho_{21,i} \Delta \ln(w/c)_{t-i} + \sum_{i=1}^2 \rho_{31,i} \Delta \ln I_{t-i}$$

$$-\lambda [\ln I_{t-1} - \pi_{11} \ln(Q/TE)_{t-1} - \pi_{21} \ln(w/c)_{t-1}] + u_{1t}^{16}$$

$$(4.7) \quad \Delta \ln L_t = \pi_{02} + \sum_{i=0}^2 \rho_{12,i} \Delta \ln Q_{t-i} + \sum_{i=0}^2 \rho_{22,i} \Delta \ln(w/c)_{t-i} + \sum_{i=0}^2 \rho_{32,i} \Delta \ln(w/l/wsl)_{t-i}$$

¹⁶ In the investment equation, w/c with $w = (w/l * L + wsl * SL) / (L + SL)$ appears as explaining variable instead of wl/c and wsl/c . The reason is that wl and wsl developed in quite a similar way in eastern Germany so that they are highly correlated.

$$\begin{aligned}
& + \sum_{i=1}^2 \rho_{42,i} \Delta \ln L_{t-i} \\
& - d_t \left[\ln L_{t-1} - \pi_{12} \ln(Q/TE)_{t-1} + \pi_{22} \ln(wl/c)_{t-1} + \pi_{32} \ln(wl/wsl)_{t-1} \right] + u_{2t} \\
(4.8) \quad \Delta \ln SL_t & = \pi_{03} + \sum_{i=0}^2 \rho_{13,i} \Delta \ln Q_{t-i} + \sum_{i=0}^2 \rho_{23,i} \Delta \ln(wsl/c)_{t-i} + \sum_{i=0}^2 \rho_{33,i} \Delta \ln(wl/wsl)_{t-i}
\end{aligned}$$

$$\begin{aligned}
& + \sum_{i=1}^2 \rho_{43,i} \Delta \ln SL_{t-i} \\
& - d_{3t} \left[\ln SL_{t-1} - \pi_{13} \ln(Q/TE)_{t-1} + \pi_{23} (wsl/c)_{t-1} - \pi_{33} (wl/wsl)_{t-1} \right] + u_{3t} \\
(4.9) \quad \Delta \ln Q_t & = \pi_{04} + \sum_{i=0}^2 \rho_{14,i} \Delta \ln wreal_{t-i} + \sum_{i=0}^2 \rho_{24,i} \Delta \ln creal_{t-i} \\
& + \sum_{i=0}^2 \rho_{34,i} \Delta \ln(P_T/P_{NT})_{t-i} + \sum_{i=1}^2 \rho_{44,i} \Delta \ln Q_{t-i} \\
& - d_t \left[\ln Q_{t-1} + \pi_{14} \ln(wreal/TE)_{t-1} - \pi_{24} \ln(creal/TE)_{t-1} + \pi_{34} \ln(P_T/P_{NT})_{t-1} \right] + u_{4t}^{17}
\end{aligned}$$

The expressions in brackets are the error-correction terms, representing the long-run equilibrium with the π -values as the long-run elasticities. Thus, the model allows to separate the short-run adjustment process of a change in relative factor prices from the long-run impact which is at the core of the

¹⁷ For the same reason as explained in footnote 11, $wreal = (wlreal * L + wslreal * SL) / (L + SL)$ appears in the equation instead of $wlreal$ and $wslreal$.

analysis. λ , d_L , d_{SL} and d_Q represent the adjustment coefficients which indicate the adjustment speed of factor demand and output towards their long-run equilibria and u_{it} represents the white noise error term.

As can be seen in the factor demand equations, the coefficients of output and technical efficiency are restricted to be equal, but of opposite signs, which results from the assumption of a Cobb-Douglas technology (see equation 3.1), and correspond to the inverse of the scale elasticity of the underlying production function. In the output equation, the ratios of factor prices and technical efficiency, i.e. factor costs in efficiency units, are taken as explaining variables (Franz and Schalk 1996).

4.3 Panel Data Issues

As stated in the previous section, the model is estimated with annual data pooled across eastern German industrial branches which are subdivided into three different pools. Estimating such a model with simple OLS would imply that all parameters — slopes and intercepts — stay constant over time and across pool-members (Hsiao 1986). Especially the latter assumption does not seem very convincing in a context of industries which — although subdivided into groups according to their factor intensities — cannot be expected to be completely homogeneous.

A way of taking account of this likely heterogeneity is to estimate the model with the intercepts π_{0i} variable across individual industries and/or across time periods. Intercepts variable across industries basically correspond to individual dummy variables, thus considering that omitted variables in the model — such as e.g. firm management capacities — may be individual-specific. Time-varying variables consider omitted conditions which may be period-specific, such as e.g.

political conditions or conditions of the business cycle. Under normal "panel conditions", i.e. with the cross-sectional dimension larger than the time-dimension, it seems reasonable to assume that individual-specific effects are somewhat more important (Janz 1997); thus, only these shall be considered in the model. The error term u_{it} can then be expressed as follows:

$$(4.10) \quad u_{it} = \alpha_i + \varepsilon_{it}$$

with α_i as the individual effect and

$$(4.11) \quad E\{\alpha_i\} = 0,$$

$$(4.12) \quad E\{\alpha_i, \alpha_j\} = \begin{cases} \sigma^2 & i = j \\ 0 & i \neq j \end{cases}$$

resp.

$$(4.13) \quad E\{\varepsilon_{it}\} = 0,$$

$$(4.14) \quad E\{\varepsilon_{it}, \varepsilon_{js}\} = \begin{cases} \sigma_{\varepsilon_{it}}^2 & i = j, t = s \\ 0 & \text{other} \end{cases}$$

$$(4.15) \quad E\{\varepsilon_{it}, \varepsilon_{js}\} = \begin{cases} \sigma_{\varepsilon_t}^2 & i = j, t = s \\ 0 & \text{other} \end{cases}$$

Furthermore, it is assumed that the error components do not correlate with each other:

$$(4.17) \quad E\{\alpha_i, \varepsilon_{jt}\} = 0 \quad \forall i, j, t.$$

Once individual-specific effects are included into the model, it is important to decide whether these effects should be treated as fixed or as random. According to Janz (1997), individual effects are fixed if they correlate with the explaining variables and random if they do not. Because this model includes lagged

dependent variables as explaining variables with which the individual effects correlate in any case, it makes sense to regard them as fixed.

Instead of estimating the fixed-effects model with an individual dummy variable for each industry, it is possible to filter the effects by transforming the variables. In a static model, this is usually done by subtracting the mean of each time series. However, if lagged dependent variables are included — as is the case in the ECM — the estimator derived from this method is biased under normal panel conditions, i.e. a large number of individuals, but only over a short period of time (Hsiao 1986). The bias results from the elimination of the fixed effects from each observation by subtracting the mean, which causes a correlation of order $(1/T)$ between the explanatory variables and the residuals. Hsiao (1986) and Janz (1997), among others, propose another method of eliminating the fixed effects from the variables in order to avoid the bias and to obtain consistent estimates: the fixed effects are eliminated by taking the first difference of each variable and the first difference of the lagged dependent variable, $(y_{i,t-1} - y_{i,t-2})$, is then instrumented by $y_{i,t-2}$ or by $(y_{i,t-2} - y_{i,t-3})$, which are both correlated with $(y_{i,t-1} - y_{i,t-2})$, but are uncorrelated with $(u_{it} - u_{i,t-1})$. The estimators thus obtained are consistent when $N \rightarrow \infty$ or $T \rightarrow \infty$ or both. The problem with this method is that — in contrast to the method of subtracting the individual means — it only uses one observation for each variable in order to remove the fixed effect. Thus, a lot of information is lost.

Because both these methods are not optimal, the one is chosen here which yielded the better results. Despite of the bias, this was the one where the fixed effects are eliminated by subtracting the individual means from the level variables. The short-run variables appear as differences anyway.

The equations which are estimated with this method look as follows:

$$\begin{aligned}
(4.18) \quad \Delta \ln I_t &= \sum_{i=0}^2 \rho_{11,i} \Delta \ln Q_{t-i} + \sum_{i=0}^2 \rho_{21,i} \Delta \ln(w/c)_{t-i} + \sum_{i=1}^2 \rho_{31,i} \Delta \ln I_{t-i} \\
&\quad - \lambda \left[\ln(I_{t-1} - \bar{I}_{t-1}) - \pi_{11} \ln((Q/TE)_{t-1} - (\bar{Q}/\bar{TE})_{t-1}) - \pi_{21} \ln((w/c)_{t-1} - (\bar{w}/\bar{c})_{t-1}) \right] \\
&\quad + (u_{1t} - \bar{u}_1)
\end{aligned}$$

$$\begin{aligned}
(4.19) \quad \Delta \ln L_t &= \sum_{i=0}^2 \rho_{12,i} \Delta \ln Q_{t-i} + \sum_{i=0}^2 \rho_{22,i} \Delta \ln(w/c)_{t-i} + \sum_{i=0}^2 \rho_{32,i} \Delta \ln(wl/wsl)_{t-i} \\
&\quad + \sum_{i=1}^2 \rho_{42,i} \Delta \ln L_{t-i} \\
&\quad - d_L \left[\ln(L_{t-1} - \bar{L}_{t-1}) - \pi_{12} \ln((Q/TE)_{t-1} - (\bar{Q}/\bar{TE})_{t-1}) \right. \\
&\quad \left. + \pi_{22} \ln((wl/c)_{t-1} - (\bar{w}\bar{l}/\bar{c})_{t-1}) + \pi_{32} \ln((wl/wsl)_{t-1} - (\bar{w}\bar{l}/\bar{w}\bar{s}\bar{l})_{t-1}) \right] \\
&\quad + (u_{2t} - \bar{u}_2)
\end{aligned}$$

$$\begin{aligned}
(4.20) \quad \Delta \ln SL_t &= \sum_{i=0}^2 \rho_{13,i} \Delta \ln Q_{t-i} + \sum_{i=0}^2 \rho_{23,i} \Delta \ln(wsl/c)_{t-i} + \sum_{i=0}^2 \rho_{33,i} \Delta \ln(wl/wsl)_{t-i} \\
&\quad + \sum_{i=1}^2 \rho_{43,i} \Delta \ln SL_{t-i} \\
&\quad - d_{SL} \left[\ln(SL_{t-1} - \bar{S}L_{t-1}) - \pi_{13} \ln((Q/TE)_{t-1} - (\bar{Q}/\bar{TE})_{t-1}) \right. \\
&\quad \left. + \pi_{23} \ln((wsl/c)_{t-1} - (\bar{w}\bar{s}\bar{l}/\bar{c})_{t-1}) - \pi_{33} \ln((wl/wsl)_{t-1} - (\bar{w}\bar{l}/\bar{w}\bar{s}\bar{l})_{t-1}) \right] \\
&\quad + (u_{3t} - \bar{u}_3)
\end{aligned}$$

$$\begin{aligned}
 (4.21) \quad \Delta \ln Q_t = & \sum_{i=0}^2 \rho_{14,i} \Delta \ln wreal_{t-i} + \sum_{i=0}^2 \rho_{24,i} \Delta \ln creal_{t-i} \\
 & + \sum_{i=0}^2 \rho_{34,i} \Delta \ln (P_T / P_{NT})_{t-i} + \sum_{i=1}^2 \rho_{44,i} \Delta \ln Q_{t-i} \\
 & - d_0 \left[\begin{array}{l} \ln(Q_{t-1} - \bar{Q}_{t-1}) + \pi_{14} \ln(wreal / TE)_{t-1} - (w\bar{e}al / \bar{TE})_{t-1} \\ -\pi_{24} \ln(creal / TE)_{t-1} - (cr\bar{e}al / \bar{TE})_{t-1} + \pi_{34} \ln((P_T / P_{NT})_{t-1} - (\bar{P}_T / \bar{P}_{NT})_{t-1}) \end{array} \right] \\
 & + (u_{4t} - \bar{u}_4)
 \end{aligned}$$

4.4 Testing for Cointegration

Estimating an ECM and interpreting the error correction term as a long-run equilibrium implies that first, one has to determine the order of integration of the level variables in the model and to test whether these variables are cointegrated.

If a variable is integrated of order 0 ($I(0)$), it follows a stationary process, i.e. it does not exhibit any trend-variation. Mean, variance and covariance of the time series are then not a function of time. If a variable is integrated of order d ($I(d)$), it follows a non-stationary process, but becomes stationary upon being differenced d times.

For "classical" regression methods, stationarity is an important pre-requisite for having an equilibrium. However, many economic time series are in fact non-stationary — often $I(1)$, i.e. they become stationary when being differenced once. In an ECM estimation, $I(1)$ -variables are only problematic concerning the level variables in the error correction term because all other variables appear as differences. For this reason, it has to be tested whether the error correction term

represents a cointegration relationship between the level variables. Cointegration means that there exists a linear combination of $I(1)$ -variables which itself is stationary; in this case, the long-run relation of the level variables in the error correction term would be stable (Hansen 1993; Deitmer 1992).

In order to find out the order of integration of the log linear model variables, an augmented Dickey-Fuller (ADF) test with individual-specific intercepts is applied. The results for the three industry-pools, which are presented in the Tables 7–9, clearly show that most of the model variables are $I(1)$. However, some wage and labour variables for the skilled-labour- and capital-intensive industries follow a stationary process.¹⁸

Although not all variables are $I(1)$, it still makes sense to apply a cointegration analysis because the stationary variables may influence the cointegration relationships of the cointegrated variables. It also has to be noted in this context that an estimation of an ECM generally makes sense for stationary level variables, too, if it is economically plausible to assume a long-run equilibrium and a short-run adjustment process. The error correction term can then be interpreted as a long-run equilibrium even without cointegration (Hansen (1993)).¹⁹

¹⁸ The only variable which cannot be clearly excluded from being integrated of a higher order than 1 is output in the skilled-labour-intensive industries. However, since the results are based on very few observations and since the critical values are not exactly given for the cross-section and time dimensions of this industry pool, it is assumed here to be $I(1)$.

¹⁹ This is an important point in the analysis: If one takes into account that the time series used here cover only six years and that cointegration tests are asymptotic tests assuming infinite time series, it might not make sense to apply integration and cointegration analysis but rather to assume that the short time series for eastern Germany are stationary.

Table 7 – Labour-intensive industries

I(1), individual-specific intercepts	t ^a	Lags
ln I	-2.19	2
ln L	-3.72	1
ln SL	-4.97	1
ln Q	-2.95	0
ln c	-4.47	2
ln wl	-3.00	2
ln wsl	-1.13	2
ln w	-1.30	2
I(2), individual-specific intercepts		
Δ ln I	-8.06**	0
Δ ln L	-6.02**	0
Δ ln SL	-8.15**	0
Δ ln Q	-6.93**	0
Δ ln c	-35.82**	1
Δ ln wl	-6.18**	0
Δ ln wsl	-8.98**	1
Δ ln w	-8.17**	0

^aCritical values for ADF-tests with panel data are reported by Levin and Lin (1992). The critical t-value with individual-specific intercepts (j=10, t=5) at the 5 percent level is -5.1, at the 10 percent level -4.94. The value for t=6 is not reported; it can be expected to be very slightly higher.

Table 8 – Skilled-labour-intensive industries

I(1), individual-specific intercepts	t^a	Lags
ln I	-3.20	0
ln L	-2.90	1
ln SL	-5.65**	2
ln Q	-1.74	0
ln c	-1.63	2
ln wl	-5.40**	2
ln wsl	-6.15**	2
ln w	-6.31**	0
I(2), individual-specific intercepts		
Δ ln I	-4.84**	0
Δ ln L	-4.70**	1
Δ ln SL	-6.19**	0
Δ ln Q	-4.05(?)	0
Δ ln c	-26.69**	1
Δ ln wl	-4.28*	0
Δ ln wsl	-14.67**	0
Δ ln w	-13.95**	0

^aThe critical t-values with individual-specific intercepts (j=5, t=5, resp. j=10, t=5) at the 5 percent level are -3.84, resp. -5.10, at the 10 percent level -3.69, resp. -4.94; for j=7 as in this case it will be in-between these values. The values for t=6 are not reported; they can be expected to be very slightly higher.

Table 9 – Capital-intensive industries

I(1), individual-specific intercepts	t ^a	Lags
ln I	-4.20	1
ln L	-6.25**	1
ln SL	-5.29	1
ln Q	-2.00	0
ln c	-1.77	2
ln wl	-3.64	2
ln wsl	-17.98**	0
ln w	-17.62**	0
I(2), individual-specific intercepts		
$\Delta \ln I$	-7.88**	0
$\Delta \ln L$	-7.94**	1
$\Delta \ln SL$	-9.47**	0
$\Delta \ln Q$	-6.35**	0
$\Delta \ln c$	-16.93**	0
$\Delta \ln wl$	-6.30**	0
$\Delta \ln wsl$	-12.94**	0
$\Delta \ln w$	-12.15**	0

^aThe critical t-values with individual-specific intercepts (j=10, t=5, resp. j=15, t=5) at the 5 percent level are -5.10, resp. -6.06, at the 10 percent level -4.94, resp. -5.89; for j=12 as in this case it will be in-between these values. The values for t=6 are not reported; they can be expected to be very slightly higher.

In order to test for cointegration, Kremers, Ericsson and Dolado (1992) propose a t-test based on the OLS-estimates of the coefficient of the lagged dependent variable. The null hypothesis of no cointegration is rejected if the coefficient is significantly negative. In the model, such a test is effected for the investment, labour and skilled-labour equations as well as for the output equations of all industry pools. The estimated t-values are given in Table 10. For all factor demand and output equations, the null hypothesis of no cointegration can be rejected and we can assume stable long-run relationships.

Table 10 – Kremers-test for cointegration of the model equations, estimated t-values

	Capital-intensive industries	Labour-intensive industries	Skilled-labour-intensive industries
Investment	-6.19**	-3.47**	-6.42**
Labour demand	-3.34*	-3.65**	-3.10 *
Skilled-labour demand	-4.89**	-4.20**	-4.63**
Output	-5.81**	-4.08**	-3.25*

A single (double) asterisk indicates that the null hypothesis is rejected at the 10 (5) percent level.

4.5 Results of the Interdependent Model

Because of the Cobb-Douglas functional form assumed in the model, it will be necessary to impose several cross-equation restrictions on the factor demand equations. These concern the output elasticities, which have to be equal in all three factor demand equations, as well as the factor price elasticities. To impose these restrictions, it is necessary to estimate the factor demand equations interdependently as a system. The interdependent model in a general form can be expressed as:

$$(4.22) \quad B^*(L) \Delta y_t = C^*(L) \Delta x_t + \alpha [\Gamma' y_{t-1} + B' x_{t-1}] + u_t$$

where $y_t = (I, L, SL)$, $x_t = (Q/TE, w/c, wl/c, wsl/c, wl/wsl)$ and $B^*(L), C^*(L), \alpha, \Gamma, B'$ are the parameter matrices.

The estimation method used is three-stage least squares for several reasons. First, cross-equation restrictions can be imposed; second, this method increases efficiency of the estimated parameters because it takes account of cross-equation correlations of the disturbances which are likely to exist across factor demand equations (Berndt 1991).

First now, the results of the interdependent estimation of the ECM without cross-equation restrictions will be presented, then the results of the independent estimation of the output equations will be given and finally, the long-run parameters of the restricted model will be derived by estimating a Bewley-transform of the ECM.

Three-stage least squares estimation of model (4.22) yields equations (4.23) to (4.25) for the labour-intensive industries, equations (4.26) to (4.28) for the skilled-labour-intensive industries and equations (4.29) to (4.31) for the capital-intensive industries.

Labour-intensive industries

$$(4.23) \quad \Delta \ln I = 0.39 \Delta \ln I_{-1} + 0.37 \Delta \ln I_{-2} \\ \quad \quad \quad (1.33) \quad \quad \quad (2.03) \\ -1.40 \left[\ln(I_{-1} - \bar{I}_{-1}) - 0.01 \ln\left(\frac{Q}{TE}\right)_{-1} - \left(\frac{\bar{Q}}{\bar{TE}}\right)_{-1} - 0.19 \ln\left(\frac{w}{c}\right)_{-1} - \left(\frac{\bar{w}}{\bar{c}}\right)_{-1} \right] \\ \quad \quad \quad (-3.86) \quad \quad \quad (-0.11) \quad \quad \quad (-1.51)$$

$$\bar{R}^2 = 0.45 \quad \rho(LM(1)) = 0.00 \quad Breusch - Pagan = 0.58$$

$$(4.24) \quad \Delta \ln L_t = 1.00 \Delta \ln(wl/c)_{-1} + 0.53 \Delta \ln(wl/wsl)_{-2} + 0.71 \Delta \ln L_{-1} + 0.28 \Delta \ln L_{-2} \\ \quad \quad \quad (1.67) \quad \quad \quad (1.08) \quad \quad \quad (4.54) \quad \quad \quad (2.28) \\ -0.94 \left[\ln(L_{-1} - \bar{L}_{-1}) - 0.25 \ln\left(\frac{Q}{TE}\right)_{-1} - \left(\frac{\bar{Q}}{\bar{TE}}\right)_{-1} \right] \\ \quad \quad \quad (-4.87) \quad \quad \quad (-0.88) \\ + 1.03 \ln\left(\frac{wl}{c}\right)_{-1} - \left(\frac{\bar{w}l}{\bar{c}}\right)_{-1} + 0.04 \ln\left(\frac{wl}{wsl}\right)_{-1} - \left(\frac{\bar{w}l}{\bar{w}sl}\right)_{-1} \\ \quad \quad \quad (2.48) \quad \quad \quad (0.13)$$

$$\bar{R}^2 = 0.28 \quad \rho(LM(1)) = 0.01 \quad Breusch - Pagan = 0.10$$

$$\begin{aligned}
(4.25) \quad \Delta \ln SL = & -0.18\Delta \ln Q_{-2} + 0.75\Delta \ln(wsl/c) + 0.39\Delta \ln(wsl/c)_{-1} + 0.47\Delta \ln(wl/wsl) \\
& \quad \quad \quad (-1.26) \quad \quad \quad (2.60) \quad \quad \quad (1.70) \quad \quad \quad (1.38) \\
& + 0.40\Delta \ln SL_{-1} + 0.44\Delta \ln SL_{-2} \\
& \quad \quad \quad (2.99) \quad \quad \quad (3.28) \\
& - 0.94 \left[\ln(SL_{-1} - \bar{S}L_{-1}) - 0.44 \ln\left(\frac{Q}{TE}\right)_{-1} - \left(\frac{\bar{Q}}{\bar{TE}}\right)_{-1} \right] \\
& \quad \quad \quad (-4.94) \quad \quad \quad (-3.25) \\
& + 0.35 \ln\left(\frac{wsl}{c}\right)_{-1} - \left(\frac{w\bar{s}l}{\bar{c}}\right)_{-1} - 0.12 \ln\left(\frac{wl}{wsl}\right)_{-1} - \left(\frac{\bar{w}l}{\bar{w}\bar{s}l}\right)_{-1} \Big] \\
& \quad \quad \quad (1.57) \quad \quad \quad (0.34)
\end{aligned}$$

$$\bar{R}^2 = 0.36 \quad \rho(LM(1)) = 0.01 \quad Breusch - Pagan = 0.21$$

Skilled-labour-intensive industries

$$\begin{aligned}
(4.26) \quad \Delta \ln I_t = & 1.00\Delta \ln I_{-1} + 0.60\Delta \ln I_{-2} \\
& \quad \quad \quad (8.37) \quad \quad \quad (4.53) \\
& - 1.51 \left[\ln(I_{-1} - \bar{I}_{-1}) - 0.22 \ln\left(\frac{Q}{TE}\right)_{-1} - \left(\frac{\bar{Q}}{\bar{TE}}\right)_{-1} - 0.34 \ln\left(\frac{w}{c}\right)_{-1} - \left(\frac{\bar{w}}{\bar{c}}\right)_{-1} \right] \\
& \quad \quad \quad (-6.37) \quad \quad \quad (-1.04) \quad \quad \quad (-1.69)
\end{aligned}$$

$$\bar{R}^2 = 0.77 \quad \rho(LM(1)) = 0.00 \quad Breusch - Pagan = 0.12$$

$$\begin{aligned}
(4.27) \quad \Delta \ln L = & -1.85\Delta \ln(wl/c) + 0.66\Delta \ln(wl/wsl)_{-1} \\
& \quad \quad \quad (-4.01) \quad \quad \quad (3.00) \\
& - 0.49 \left[\ln(L_{-1} - \bar{L}_{-1}) - 0.01 \ln\left(\frac{Q}{TE}\right)_{-1} - \left(\frac{\bar{Q}}{\bar{TE}}\right)_{-1} \right] \\
& \quad \quad \quad (-3.17) \quad \quad \quad (-0.01) \\
& + 1.92 \ln\left(\frac{wl}{c}\right)_{-1} - \left(\frac{\bar{w}l}{\bar{c}}\right)_{-1} + 2.09 \ln\left(\frac{wl}{wsl}\right)_{-1} - \left(\frac{\bar{w}l}{\bar{w}\bar{s}l}\right)_{-1} \Big] \\
& \quad \quad \quad (2.34) \quad \quad \quad (1.86)
\end{aligned}$$

$$\bar{R}^2 = 0.52 \quad \rho(LM(1)) = 0.04 \quad Breusch - Pagan = 0.37$$

$$\begin{aligned}
 (4.28) \quad \Delta \ln SL &= +0.97 \Delta \ln (wl / wsl) \\
 &\quad (4.82) \\
 &\quad -0.43 \left[\ln (SL_{-1} - \bar{S}L_{-1}) - 0.47 \ln \left((Q / TE)_{-1} - (\bar{Q} / \bar{TE})_{-1} \right) \right] \\
 &\quad (-2.22) \qquad \qquad \qquad (-2.21) \\
 &\quad +0.96 \ln ((wsl / c)_{-1} - (w\bar{s}l / \bar{c})_{-1}) + 0.17 \ln ((wl / wsl)_{-1} - (\bar{w}l / w\bar{s}l)_{-1}) \\
 &\quad (2.17) \qquad \qquad \qquad (0.23)
 \end{aligned}$$

$$\bar{R}^2 = 0.28 \quad \rho(LM(1)) = 0.00 \quad Breusch - Pagan = 0.82$$

Capital-intensive industries

$$\begin{aligned}
 (4.29) \quad \Delta \ln I &= 0.93 \Delta \ln I_{-1} + 0.30 \Delta \ln I_{-2} \\
 &\quad (5.47) \qquad \qquad \qquad (2.22) \\
 &\quad -1.54 \left[\ln (I_{-1} - \bar{I}_{-1}) - 0.08 \ln \left((Q / TE)_{-1} - (\bar{Q} / \bar{TE})_{-1} \right) - 0.37 \ln ((w/c)_{-1} - (\bar{w}/\bar{c})_{-1}) \right] \\
 &\quad (-6.78) \qquad \qquad \qquad (-0.45) \qquad \qquad \qquad (-1.77)
 \end{aligned}$$

$$\bar{R}^2 = 0.55 \quad \rho(LM(1)) = 0.00 \quad Breusch - Pagan = 0.46$$

$$\begin{aligned}
 (4.30) \quad \Delta \ln L &= 0.53 \Delta \ln Q + 0.36 \Delta \ln L_{-2} \\
 &\quad (3.67) \qquad \qquad \qquad (6.47) \\
 &\quad -0.73 \left[\ln (L_{-1} - \bar{L}_{-1}) - 0.53 \ln \left((Q / TE)_{-1} - (\bar{Q} / \bar{TE})_{-1} \right) \right] \\
 &\quad (-3.87) \qquad \qquad \qquad (-4.00) \\
 &\quad +1.13 \ln ((wl / c)_{-1} - (\bar{w}l / \bar{c})_{-1}) + 0.26 \ln ((wl / wsl)_{-1} - (\bar{w}l / w\bar{s}l)_{-1}) \\
 &\quad (3.81) \qquad \qquad \qquad (-0.48)
 \end{aligned}$$

$$\bar{R}^2 = 0.46 \quad \rho(LM(1)) = 0.01 \quad Breusch - Pagan = 0.32$$

(4.31)

$$\Delta \ln SL = 0.58 \Delta \ln Q - 0.45 \Delta \ln Q_{-1} + 0.38 \Delta \ln (wsl / c)_{-2} + 0.52 \Delta \ln SL_{-1} + 0.30 \Delta \ln SL_{-2}$$

$$(6.06) \quad (-4.30) \quad (2.89) \quad (4.90) \quad (3.46)$$

$$-0.81 \left[\ln (SL_{-1} - \bar{S}L_{-1}) - 0.76 \ln \left((Q / TE)_{-1} - (\bar{Q} / \bar{TE})_{-1} \right) \right]$$

$$(-5.81) \quad (-6.39)$$

$$+0.22 \ln \left((wsl / c)_{-1} - (w\bar{s}l / \bar{c})_{-1} \right) - 0.15 \ln \left((wl / wsl)_{-1} - (\bar{w}l / w\bar{s}l)_{-1} \right) \Big]$$

$$(0.96) \quad (-0.39)$$

$$\bar{R}^2 = 0.68 \quad \rho(LM(1)) = 0.03 \quad Breusch - Pagan = 0.76$$

In the following analysis, only the long-run elasticities will be focused. The short-run adjustment will not be commented in detail.

It is quite obvious that not all long-run coefficients are significant²⁰. The results strongly suggest that whereas capital and labour are substitutable, there are complementarities between skilled labour and labour as well as capital in some cases. Moreover, the output effects on factor demand in the unrestricted model are mostly very weak — except concerning skilled labour — which contradicts most empirical findings for western countries, reporting output elasticities near unity. Output does not yet seem to be an important determinant of factor demand in eastern Germany which could be due to the enormous restructuring activities that firms have gone through. So far, only skilled labour benefits from output increases — which fits with the notion of eastern Germany turning into a high-wage-high-skill economy.

²⁰ Coefficients are regarded as significant if they are significant at the 10 percent level.

Labour demand is in most cases strongly determined by the ratio of wages and capital costs. This is a very plausible result if one considers the problem of overmanning across all eastern German industries. By contrast, skilled-labour demand in the capital- and labour-intensive industries does not at all react to changes in relative factor prices, indicating that it is not subject to substitutability with either capital or unskilled labour. However, an ex-ante substitutability is given with capital in the skilled-labour-intensive industries. The elasticities of investment demand as to relative factor prices are overall rather low.

The size and significance of the adjustment coefficients indicate that factor demand reacts very strongly to disequilibrium in all industries. The adjustment of labour and skilled-labour demand is particularly fast in the labour- and capital-intensive industries. This reflects how massive overemployment was in the former GDR and how massively it was reduced during the transition period. In the skilled-labour-intensive industries, adjustment seems to be somewhat slower. This might be due to stricter rules by the Treuhand for privatized firms in some key industries (e.g. machinery) in order to save jobs or due to government-funded R&D-institutions meant to ensure continuous employment of human capital (so-called "Forschungs-GmbHs"). A rather astonishing result is the coefficient of investment demand exceeding one in all industries, which suggests that investment is somehow overshooting its long-run values, but is still stable. At first glance, this seems to be a little odd. However, if one considers the partly erratic development of investment in eastern Germany, which did not always follow regular economic conditions, but was subject to exceptional developments such as large investment projects e.g. to restructure an industrial complex, it becomes more intuitive. Such projects were often

induced by policy decisions in the course of economic transition — like specific industrial policy measures or the policy of the Treuhand.

Table 11 now gives the long-run elasticities for the restricted model from the Bewley-transformation of the ECM. Testing for the validity of the restrictions on factor demand yields a χ^2 -statistic of 2.33 for the skilled-labour-intensive industries with a significance level of 0.68. Thus, the null-hypothesis of validity of the restrictions cannot be rejected. For the other industries, however, the χ^2 -statistics are not significant. Faini and Schiantarelli (1985) suggest in this context that it is very likely for such restrictions to hold at the level of a single firm but unlikely at an aggregated level.

Table 11 – Long-run elasticities in the restricted model

	I	L	SL
<i>Labour-intensive industries</i>			
Long-run factor price elasticities	$\eta_{r,w} _{r=\bar{r}} = 0.22$ $\eta_{r,c} _{r=\bar{r}} = -0.22$	$\eta_{L,w} _{r=\bar{r}} = -0.54$ $\eta_{L,w,l} _{r=\bar{r}} = n.s.$ $\eta_{L,c} _{r=\bar{r}} = 0.54$	$\eta_{SL,w} _{r=\bar{r}} = n.s.$ $\eta_{SL,w,l} _{r=\bar{r}} = -0.54$ $\eta_{SL,c} _{r=\bar{r}} = 0.54$
Long-run output elasticities	$\eta_{r,Q} = 0.18$	$\eta_{L,Q} = 0.18$	$\eta_{SL,Q} = 0.18$
<i>Skilled-labour-intensive industries</i>			
Factor price elasticities	$\eta_{r,w} _{r=\bar{r}} = 0.44$ $\eta_{r,c} _{r=\bar{r}} = -0.44$	$\eta_{L,w} _{r=\bar{r}} = -2.32$ $\eta_{L,w,l} _{r=\bar{r}} = 1.13$ $\eta_{L,c} _{r=\bar{r}} = 1.02$	$\eta_{SL,w} _{r=\bar{r}} = n.s.$ $\eta_{SL,w,l} _{r=\bar{r}} = -1.29$ $\eta_{SL,c} _{r=\bar{r}} = 1.29$
Output elasticities	$\eta_{r,Q} = 0.34$	$\eta_{L,Q} = 0.34$	$\eta_{SL,Q} = 0.34$
<i>Capital-intensive industries</i>			
Long-run factor price elasticities	$\eta_{r,w} _{r=\bar{r}} = 0.67$ $\eta_{r,c} _{r=\bar{r}} = -0.67$	$\eta_{L,w} _{r=\bar{r}} = -0.67$ $\eta_{L,w,l} _{r=\bar{r}} = n.s.$ $\eta_{L,c} _{r=\bar{r}} = 0.67$	$\eta_{SL,w} _{r=\bar{r}} = 0.55$ $\eta_{SL,w,l} _{r=\bar{r}} = -1.22$ $\eta_{SL,c} _{r=\bar{r}} = 0.67$
Long-run output elasticities	$\eta_{r,Q} = 0.46$	$\eta_{L,Q} = 0.46$	$\eta_{SL,Q} = 0.46$
n.s. = not significant			

The independent estimation of the output equations yields the following results:

Labour-intensive industries

$$\begin{aligned}
 (4.32) \quad \Delta \ln Q = & 0.53 \Delta \ln wreal + 0.36 \Delta \ln Q_{-1} + 0.36 \Delta \ln Q_{-2} \\
 & \quad (2.50) \qquad \quad (2.41) \qquad \quad (2.97) \\
 & -0.61 \left[\ln(Q_{-1} - \bar{Q}_{-1}) - 1.18 \ln(wreal / TE)_{-1} - (wr\bar{e}al / \bar{T}E)_{-1} \right] \\
 & \quad (-4.08) \qquad \quad (-1.68) \\
 & + 0.73 \ln(creal / TE)_{-1} - (cr\bar{e}al / \bar{T}E)_{-1} - 2.02 \ln(P_T / P_{NT})_{-1} - (\bar{P}_T / \bar{P}_{NT})_{-1} \\
 & \quad (1.96) \qquad \qquad \qquad (-1.45)
 \end{aligned}$$

$$\bar{R}^2 = 0.55 \quad \rho(LM(1)) = 0.06 \quad Breusch - Pagan = 0.51$$

Skilled-labour-intensive industries

$$\begin{aligned}
 (4.33) \quad \Delta \ln Q = & 0.39 \Delta \ln wreal \\
 & \quad (3.21) \\
 & -0.62 \left[\ln(Q_{-1} - \bar{Q}_{-1}) - 1.05 \ln(wreal / TE)_{-1} - (wr\bar{e}al / \bar{T}E)_{-1} \right] \\
 & \quad (-3.25) \qquad \quad (-1.80) \\
 & + 0.73 \ln(creal / TE)_{-1} - (cr\bar{e}al / \bar{T}E)_{-1} + 2.27 \ln(P_T / P_{NT})_{-1} - (\bar{P}_T / \bar{P}_{NT})_{-1} \\
 & \quad (2.28) \qquad \qquad \qquad (0.65)
 \end{aligned}$$

$$\bar{R}^2 = 0.29 \quad \rho(LM(1)) = 0.00 \quad Breusch - Pagan = 0.40$$

Capital-intensive industries

$$\begin{aligned}
 (4.34) \quad \Delta \ln Q = & 0.62 \Delta \ln Q_{-1} - 0.37 \Delta \ln creal \\
 & \quad (6.39) \qquad \quad (-1.87) \\
 & -0.59 \left[\ln(Q_{-1} - \bar{Q}_{-1}) - 1.00 \ln(wreal / TE)_{-1} - (wr\bar{e}al / \bar{T}E)_{-1} \right] \\
 & \quad (-5.81) \qquad \quad (-1.50)
 \end{aligned}$$

$$+0.63 \ln\left(\frac{creal}{TE}\right)_{-1} - \left(\frac{c\bar{e}al}{\bar{TE}}\right)_{-1} + 0.55 \ln\left(\frac{P_r}{P_{MT}}\right)_{-1} - \left(\frac{\bar{P}_r}{\bar{P}_{MT}}\right)_{-1} \Bigg]$$

(2.01) (0.66)

$$\bar{R}^2 = 0.62 \quad \rho(LM(1)) = 0.26 \quad Breusch - Pagan = 0.32$$

Just as labour demand, output in all industries is adjusting very quickly. The results for the long-run coefficients are ambiguous: The user cost of capital show the expected sign and prove to be significant in all industries. Unexpectedly, they are strongest in the capital-intensive industries. Capital costs thus seem to be an important aspect of production considerations in all firms. This could be caused by the importance of new equipment in most eastern German industries and by the possibility of establishing rather capital-intensive technologies in eastern Germany in industries which are usually classified as labour- or skilled-labour-intensive. Good examples are the motor vehicle industry and the electronics industry, for which capital costs must have become a very important cost factor meanwhile.

Surprisingly, wage increases have a positive effect on output which is strongest in the labour-intensive industries. The reason might be that the variable reflects both supply and demand effects: On the one hand, a wage increase as took place in eastern Germany after unification means an increase in production cost, which has a negative impact on output, on the other hand it means an increase in income, which has a positive impact on output. Obviously, the latter effect prevailed in eastern Germany during transformation. Another possible explanation is the lacking differentiation of the wages variable. An increase in the wages of skilled labour — which are most strongly represented in the wages

variable — as to the wages of unskilled labour could enhance productivity and thus lead to rising output.

A Dutch disease indicated by the relative prices of tradeable and non-tradeable goods cannot be diagnosed. A fall of relative prices for tradeables as was observed in eastern Germany after reunification has a negative — but insignificant — impact on output in the labour-intensive industries and a positive, also insignificant impact in all others. At first glance, this seems to be rather surprising because the pool of the labour-intensive industries contains many industries producing goods which are usually not traded to a large extent, such as printing products, processed wood, plastics and metal products (Klodt, Stehn et al. 1994). One would expect that the Dutch disease problem caused by a fall in the relative price of tradeable goods rather strikes those goods which are extensively traded. However, it could be that in the industries which are strongly subject to trade another effect has to be taken into account: a fall in the relative price of tradeable goods increases the chances to export and thus the incentive to produce more. This would explain the negative (but insignificant) coefficient of the price variable in the capital- and skilled-labour-intensive industries.

4.6 Net Effects

The net effects of factor prices on factor demand — including the substitution as well as the output effect — are now calculated by taking the long-run

elasticities of the factor demand model and the results of the output equations together.¹⁸

Table 12 – Net effects of the restricted and unrestricted model

	I		L		SL	
	restricted model	unrestricted model	restricted model	unrestricted model	restricted model	unrestricted model
Net effects, labour-intensive industries	$\eta_{I,w} = 0.43$	$\eta_{I,w} = n.s.$	$\eta_{L,w} = -0.33$	$\eta_{L,w} = -1.02$	$\eta_{SL,w} = 0.21$	$\eta_{SL,w} = 0.52$
	$\eta_{I,c} = -0.35$	$\eta_{I,c} = n.s.$	$\eta_{L,w} = 0.21$	$\eta_{L,w} = n.s.$	$\eta_{SL,w} = -0.33$	$\eta_{SL,w} = 0.52$
			$\eta_{L,c} = 0.41$	$\eta_{L,c} = 1.03$	$\eta_{SL,c} = 0.41$	$\eta_{SL,c} = -0.32$
	$\eta_{I,TE} = -0.26$	$\eta_{I,TE} = n.s.$	$\eta_{L,TE} = -0.26$	$\eta_{L,TE} = n.s.$	$\eta_{SL,TE} = -0.26$	$\eta_{SL,TE} = -0.64$
Net effects, skilled-labour-intensive industries	$\eta_{I,w} = 0.79$	$\eta_{I,w} = 0.34$	$\eta_{L,w} = -2.07$	$\eta_{L,w} = -4.01$	$\eta_{SL,w} = 0.36$	$\eta_{SL,w} = 0.49$
	$\eta_{I,c} = -0.69$	$\eta_{I,c} = -0.34$	$\eta_{L,w} = 1.49$	$\eta_{L,w} = 2.09$	$\eta_{SL,w} = -0.93$	$\eta_{SL,w} = -0.47$
			$\eta_{L,c} = 1.04$	$\eta_{L,c} = 1.92$	$\eta_{SL,c} = 1.04$	$\eta_{SL,c} = 0.62$
	$\eta_{I,TE} = -0.45$	$\eta_{I,TE} = n.s.$	$\eta_{L,TE} = -0.45$	$\eta_{L,TE} = n.s.$	$\eta_{SL,TE} = -0.45$	$\eta_{SL,TE} = -0.62$
Net effects, capital-intensive industries	$\eta_{I,w} = 0.37$	$\eta_{I,w} = 0.37$	$\eta_{L,w} = -0.67$	$\eta_{L,w} = -1.13$	$\eta_{SL,w} = 0.55$	$\eta_{SL,w} = n.s.$
	$\eta_{I,c} = -0.96$	$\eta_{I,c} = -0.37$	$\eta_{L,w} = n.s.$	$\eta_{L,w} = n.s.$	$\eta_{SL,w} = -1.22$	$\eta_{SL,w} = n.s.$
			$\eta_{L,c} = 0.38$	$\eta_{L,c} = 0.80$	$\eta_{SL,c} = 0.38$	$\eta_{SL,c} = -0.48$
	$\eta_{I,TE} = -0.17$	$\eta_{I,TE} = n.s.$	$\eta_{L,TE} = -0.17$	$\eta_{L,TE} = -0.20$	$\eta_{SL,TE} = -0.17$	$\eta_{SL,TE} = -0.28$

n.s. = not significant

Table 12 presents the net effects for all industries for the restricted as well as for the unrestricted model because it is not certain which one is definitely valid here. If one assumes that the restrictions are all valid for the model since they are valid at the firm level, the long-run elasticities of the restricted factor

¹⁸ The net effect of a one percent change in the user cost of capital on investment is calculated as: $\eta_{I,c} = \eta_{I,c}|_{r=\bar{r}} + \eta_{I,Q} * \eta_{Q,c}$ and accordingly for the other net effects.

demand model can be used for the calculation of the net effects which in their tendency do not differ too much from the unrestricted results — except for the significance of the output variable in the factor demand equations (see Table 11).

According to the restricted as well as the unrestricted model, a change in the user cost of capital as caused e.g. by capital subsidization does not have a very large impact on investment demand in most cases; as expected, it is strongest in the capital-intensive industries.

The negative impact of respective wages on labour and skilled-labour demand is often quite strong, reflecting the enormous overemployment in eastern German firms and the possibilities to substitute capital especially for unskilled labour. New equipment offers large potentials for rationalization here so that a wage policy as it is must necessarily have grave consequences for the labour market. The substitution effect of capital for skilled labour is strongest in the skilled-labour-intensive industries indicating a choice of technology: In these industries in particular, it is possible to introduce very capital-intensive technologies and to operate high-tech enterprises with relatively little personnel. There are quite a few examples among famous investments in eastern Germany which illustrate this possibility, such as the automobile factories of Opel in Eisenach and VW in Mosel and the chip production of Siemens and AMD in Dresden. A striking result concerning wage effects in the unrestricted model is the positive impact of a rise in its wages on skilled labour in the labour-intensive industries. This is because the direct effect of rising wages — a reduction in employment — is offset by a positive output effect, either caused by higher income and demand or by increased productivity (see section 4.5), thus giving reason to believe that there could be an argument for a stronger wage differentiation in favour of skilled-labour wages.

The most interesting finding in the restricted model is the fact that the substitution effect of a reduction of capital costs on labour and skilled-labour demand is never outweighed by the output effect — the substitution effect prevails even in the capital-intensive industries. The consequence is that a reduction of capital costs by capital subsidies does not have any positive impact on employment in eastern German manufacturing, but all in all reduces it quite strongly.

The result is different looking at the unrestricted model where the substitution effect of a capital cost reduction is indeed outweighed by its output effect in both the capital- and the labour-intensive industries. However, this is only valid for skilled, not at all for unskilled labour. According to this result, capital subsidies lead to a rise in employment of skilled labour in labour- and especially — as one would have expected — in capital-intensive branches through a strong incentive to increase production. In the skilled-labour-intensive branches, however, the output effect is not strong enough.

In contrast to the substitutability between capital and labour, resp. skilled labour in some cases, the latter often show some complementarities between each other, especially in the capital-intensive industries. Consequently, the impact of a change in the respective "cross wages" can in some cases be neglected, in others it is only determined by the output effect.

Not surprisingly, technical progress seems to affect factors of production most strongly in the skilled-labour-intensive industries; according to the unrestricted model, it seems to be somewhat biased towards skilled-labour saving.

Obviously, the large sums of capital subsidies together with the wage policy contributed to a production structure and technology which is focused on a high capital intensity as the observations concerning investment, employment and

output in section 2 suggest. An overcompensation of the substitution effect of capital subsidies is — if at all — only conceivable for skilled labour in the capital- and surprisingly also in the labour-intensive industries, meaning that by and large, capital subsidies probably lead to a reduction of employment in eastern German firms. In this case, the explicit aim of the subsidies, namely to create and to sustain employment would be missed. It has to be noted, though, that the results of the empirical model should be interpreted carefully. The time span under estimation is very short and the ongoing process of transition certainly causes some distortions which do not well fit into equilibrium considerations. This is particularly valid because the first years after reunification are included in the data. As a consequence, the results can only describe rough trends.

5. Concluding Remarks

The target of this paper was to analyse the effects of government support in the form of capital subsidies on the production structure and on factor demand in eastern German manufacturing during transition. For this purpose, a factor demand model based on a Cobb-Douglas production function was estimated in error correction form for three different industry pools, subdivided according to their factor intensities.

The model suggests that substitution effects are strong between unskilled labour and capital and in some cases existing between skilled labour and capital (skilled-labour-intensive industries) — the latter being not so astonishing if one considers the heavy overmanning in eastern German firms which is also true for labour classified as skilled here. The most notable finding is that the substitution effect of a capital cost reduction through subsidization is — if at all, depending on the chosen model — offset by an output effect only in the

case of skilled labour in the capital- and labour-intensive industries. This result confirms the importance of skills concerning the situation on the eastern German labour market. However, in the skilled-labour-intensive industries, which in a Heckscher-Ohlin world are supposed to be the leading industries in an economy being relatively rich in human capital, the effects of decreasing capital costs cannot at all be seen in a positive light regarding employment. This seems to be mainly due to strong substitution possibilities between labour and capital in these industries which are not compensated otherwise.

All in all, the massive capital subsidies were obviously not able to contribute unambiguously to the creation of new jobs in eastern German manufacturing. The situation becomes even less promising for the labour market in the east — and especially for unskilled workers — if one takes into account that the wage policy was far from being reasonable in the first years after reunification and that further dismissals of employees in the construction sector, which suffers from overcapacities now that its reunification boom is over, are to be expected.

It should not be concluded, though, that investment subsidies were not at all a useful policy instrument at the beginning of the transition process when the capital stock had to be built up from scratch. However, they were in many cases overtaxed with the expectation of creating extra jobs in an economy where overmanning was extreme and the capital stock was to be rebuilt completely, implying numerous possibilities for the entrepreneur to choose a production technology — i.e. to choose whether he wants to produce with relatively more labour or capital.

It remains to be asked what the programs to support the restructuring of a competitive industrial base should look like in the future. Due to the level of aggregation in the analysis, the effects of each subsidy or tax cannot be extracted individually. This has to be left for further research. Only some general

statements based on the hypothesis that an economy has potential comparative advantages in those industries which employ its relatively abundant factor intensively can be made. This hypothesis postulates that, in order to build up a competitive export base which is in line with eastern Germany's comparative advantages, skilled-labour-intensive firms certainly have to play a key role. Government support as it is has obviously contributed to the trouble of these industries during the transformation process and thus, to a distortion of the production structure. For the competitiveness of the eastern German economy, however, it seems to be important that enough qualified jobs are created especially in these industries - instead of being replaced by relatively cheaper capital.

Appendix

Table A1 – Conditions of Subsidized Credits

	1991	1992	1993	1994	1995	1996
KfW Investitionsprogramm (investment programme)	i=7.5 n=10	i=7.5 n=10	-	-	-	-
KfW Mittelstandsprogramm (programme for SMEs)	i=8 n=10	i=7.75 n=10	i=6.25 n=10	i=6 n=10	i=5.75 n=10	i=5.5 n=10
DtA Existenzgründungsprogramm (programme for newly founded firms)	i=8 n=10	i=8 n=10	i=6.25 n=10	i=6.15 n=10	i=5.75 n=10	i=5.25 n=10
ERP-Programme (KfW, DtA)	i=7.5 n=15	i=7.5 n=15	i=6.25 n=15	i=6 n=15	i=6 n=15	i=5.5 n=15

i=interest rate; n=life of credit

Note: Conditions of DtA-Eigenkapitalhilfeprogramm (equity program):

i=0	first to third year
i=2	fourth year
i=3	fifth year
i=5	sixth year

Table A2 – Shares of eastern German manufacturing firms making profits, 1991–1996 (in percent)

	1991	1992	1993	1994	1995	1996
Firms reporting profits	16	34	43	37	44 ^a	39 ^a

^a Expected shares

Source: DIW.

Table A3 – User cost of capital in eastern German industries including capital subsidies, 1991–1996

	user cost of capital, "with"					
	1991	1992	1993	1994	1995	1996
	<i>labour-intensive industries</i>					
Clothing	8.91	9.93	9.76	8.07	8.25	7.66
Printing	9.02	9.53	9.59	7.81	8.16	7.58
Pottery	8.94	9.52	9.46	7.83	8.17	7.58
Rubber	8.91	9.71	9.68	8.08	8.41	7.81
Metal products	8.94	9.58	9.54	7.96	8.24	7.65
Plastics	8.91	9.57	9.68	8.05	8.38	7.78
Wood processing	8.88	9.61	9.59	7.99	8.32	7.73
Musical instruments, toys, etc.	8.43	9.66	9.91	8.19	8.56	7.95
Paper processing	8.79	9.57	9.66	7.87	8.27	7.68
Rolling mills etc.	8.91	9.56	9.55	8.13	8.21	7.63
	<i>skilled-labour-intensive industries</i>					
Office machinery	8.27	9.62	9.57	7.51	7.58	7.04
Electrical engineering, electronics	9.06	9.74	9.76	7.97	8.10	7.51
Machinery	8.88	9.66	9.67	8.06	8.04	7.46
Shipbuilding	9.13	9.53	9.47	7.88	7.80	7.23
Motor vehicles	8.50	9.68	9.52	7.97	8.04	7.46
Mechanics, optical instruments	8.80	9.51	9.83	7.93	8.24	7.65
Constructional steel	8.83	9.74	9.58	7.98	8.20	7.62
	<i>capital-intensive industries</i>					
Chemicals	8.97	9.55	9.48	7.87	8.01	7.44
Iron and steel	8.87	9.60	9.53	8.14	7.99	7.41
Food, beverages	8.97	9.61	9.54	7.74	7.85	7.28
Quarrying	8.43	9.54	9.64	7.78	8.02	7.44
Foundries	8.87	9.68	9.67	8.13	7.98	7.40
Glass	8.94	9.65	9.41	7.88	7.99	7.41
Wood	8.88	9.65	8.91	7.44	7.51	6.97
Leather	8.76	9.46	9.35	7.95	7.97	7.39
Mineral oil	9.07	9.47	9.46	7.97	8.05	7.46
Non-ferrous metals	8.87	9.52	9.50	8.05	7.90	7.33
Textiles	8.97	9.75	9.64	8.00	8.00	7.42
Pulp and paper	8.76	9.50	9.57	7.71	7.88	7.30

Table A4 – User cost of capital in eastern German industries without capital subsidies, 1991–1996

	user cost of capital, "without"					
	1991	1992	1993	1994	1995	1996
	<i>labour-intensive industries</i>					
Clothing	11.92	12.59	13.03	11.78	11.92	10.76
Printing	11.92	12.29	12.93	11.65	11.78	10.64
Pottery	11.92	12.39	12.87	11.66	11.80	10.65
Rubber	11.92	12.63	13.14	12.02	12.16	10.98
Metal products	11.92	12.43	13.06	11.77	11.91	10.75
Plastics	11.92	12.45	13.14	11.96	12.10	10.93
Wood processing	11.92	12.47	13.13	11.88	12.02	10.86
Musical instruments, toys, etc.	11.92	12.53	13.45	12.23	12.37	11.17
Paper processing	11.92	12.37	12.97	11.80	11.94	10.78
Rolling mills etc.	11.92	12.40	12.97	11.73	11.86	10.71
	<i>skilled-labour-intensive industries</i>					
Office machinery	11.92	12.43	13.19	11.11	11.25	10.15
Electrical engineering, electronics	11.92	12.42	13.11	11.87	12.01	10.84
Machinery	11.92	12.39	13.03	11.78	11.92	10.76
Shipbuilding	11.92	12.03	12.87	11.43	11.56	10.44
Motor vehicles	11.92	12.40	13.05	11.78	11.92	10.76
Mechanics, optical instruments	11.92	12.37	13.35	11.77	11.91	10.75
Constructional steel	11.92	12.48	13.03	11.72	11.85	10.70
	<i>capital-intensive industries</i>					
Chemicals	11.92	12.37	13.05	11.82	11.95	10.79
Iron and steel	11.92	12.43	13.13	11.89	12.03	10.87
Food, beverages	11.92	12.42	13.08	11.68	11.82	10.67
Quarrying	11.92	12.46	13.29	11.94	12.08	10.91
Foundries	11.92	12.57	13.33	11.88	12.02	10.86
Glass	11.92	12.59	13.06	11.89	12.03	10.87
Wood	11.92	12.53	12.38	11.18	11.31	10.22
Leather	11.92	12.40	12.98	11.86	12.00	10.83
Mineral oil	11.92	12.51	13.27	11.98	12.12	10.95
Non-ferrous metals	11.92	12.33	13.09	11.76	11.90	10.74
Textiles	11.92	12.57	13.27	11.90	12.04	10.88
Pulp and paper	11.92	12.30	13.03	11.73	11.86	10.71

Table A5 – Reduction of user cost of capital due to capital subsidization, 1991–1996

	user cost reduction					
	1991	1992	1993	1994	1995	1996
	<i>labour-intensive industries</i>					
Clothing	0.25	0.21	0.25	0.32	0.31	0.29
Printing	0.24	0.22	0.26	0.33	0.31	0.29
Pottery	0.25	0.23	0.26	0.33	0.31	0.29
Rubber	0.25	0.23	0.26	0.33	0.31	0.29
Metal products	0.25	0.23	0.27	0.32	0.31	0.29
Plastics	0.25	0.23	0.26	0.33	0.31	0.29
Wood processing	0.26	0.23	0.27	0.33	0.31	0.29
Musical instruments, toys, etc.	0.29	0.23	0.26	0.33	0.31	0.29
Paper processing	0.26	0.23	0.26	0.33	0.31	0.29
Rolling mills etc.	0.25	0.23	0.26	0.31	0.31	0.29
	<i>skilled-labour-intensive industries</i>					
Office machinery	0.31	0.23	0.27	0.32	0.33	0.31
Electrical engineering, electronics	0.24	0.22	0.26	0.33	0.33	0.31
Machinery	0.26	0.22	0.26	0.32	0.33	0.31
Shipbuilding	0.23	0.21	0.26	0.31	0.33	0.31
Motor vehicles	0.29	0.22	0.27	0.32	0.33	0.31
Mechanics, optical instruments	0.26	0.23	0.26	0.33	0.31	0.29
Constructional steel	0.26	0.22	0.26	0.32	0.31	0.29
	<i>capital-intensive industries</i>					
Chemicals	0.25	0.23	0.27	0.33	0.33	0.31
Iron and steel	0.26	0.23	0.27	0.32	0.34	0.32
Food, beverages	0.25	0.23	0.27	0.34	0.34	0.32
Quarrying	0.29	0.23	0.27	0.35	0.34	0.32
Foundries	0.26	0.23	0.27	0.32	0.34	0.32
Glass	0.25	0.23	0.28	0.34	0.34	0.32
Wood	0.26	0.23	0.28	0.33	0.34	0.32
Leather	0.27	0.24	0.28	0.33	0.34	0.32
Mineral oil	0.24	0.24	0.29	0.33	0.34	0.32
Non-ferrous metals	0.26	0.23	0.27	0.32	0.34	0.32
Textiles	0.25	0.22	0.27	0.33	0.34	0.32
Pulp and paper	0.27	0.23	0.27	0.34	0.34	0.32

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