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Subsidization and Structural Change in Eastern German Transition: Did Economic Policy Meet Its Objectives?

by

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Abstract:
Economic policy interventions of a scale as effected in eastern Germany can be expected to have a significant impact on the economy, which may be in accordance with the objectives of the policy measures or manifest itself in distortions of several kinds. This paper analyzes the structural effects of investment subsidization as one of the core policy instruments by means of an error-correction model of factor demand and output. It intends to find out whether investment subsidization contributes to creating competitive economic structures, employment and growth or whether it just fosters an exaggerated capital intensity.

Keywords: Subsidization, transition, factor demand, substitution, panel estimation

JEL classification: E22, E23, E24, H20, C33, C51

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I. Introduction

After reunification, the eastern German economy started from a wide gap between what it had and what it needed. What it had was a base of old industries with a specialisation pattern obeying centralist plans rather than the rationale of comparative advantage, burdened by an outdated capital stock and heavy overmanning and far from being competitive according to western standards. What it needed, and still needs, points in the opposite direction: a qualified industrial base, which — being export-oriented because local markets can only offer a limited potential for growth — should be concentrated on internationally growing branches and make use of the skilled labour-force; a large number of qualified jobs which are competitive in the long run; and last not least, a self-sustaining growth process as a pre-requisite for a full economic integration with the western part of Germany.

If one takes into account the numerous inefficiencies being left from the past and the drastic changes involved in the transition from plan to market, it is obvious that there was an enormous task of economic restructuring ahead at the wake of unification and that the eastern German economy would have had trouble to cope with it on its own. In order to help through the struggle for competitiveness on national and on international markets and in order to alleviate the frictions of the painful transition process, the German government felt obliged to become active.

Next to gradually restoring the conditions which make a market economy work, such as an adequate legal and institutional system, sufficient infrastructure and private property rights, the German government tried to compensate private households for the numerous social frictions of the transition process, thus influencing the demand side of the economy and potential investors for locational disadvantages and lacking positive externalities in order to allow for a quick restructuring of the eastern German industrial base, thus influencing the supply side conditions. In this context, the German Federal Government pursued a strategy of supporting investment which was considered as the most promising strategy to foster long-term growth and employment (Gerling 1998).

Interventions of such a scale as effected in eastern Germany necessarily have a significant impact on the economy. This impact can consist of effects which are in accordance with the objectives of the policy measures, but it can also consist of distortions of several kinds.

This paper intends to analyze the structural effects of the core policy variables and to discuss whether they are in accordance or in conflict with the policy objectives. In the second section, economic policy in eastern German transition is closely examined according to objectives, extent and possible effects. The focus lies on investment subsidization as one of the key instruments of economic policy in transition and on the industrial sector for which a comparably rich data basis is available. In the third section, a theoretical model is set up which is meant to capture the impact of investment subsidization and other important variables on factor demand and production in eastern German industries; the model is empirically implemented and its results are discussed in section IV. Section V concludes.

II. Economic Policy in Eastern German Transition

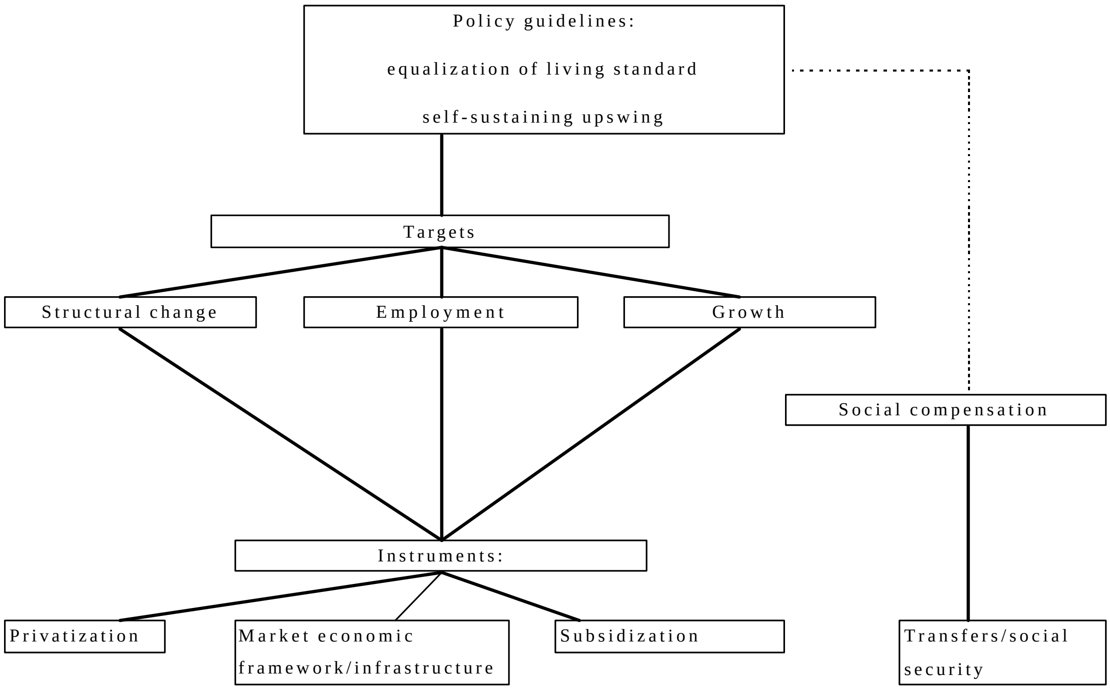
1. Objectives and Instruments

Taking a closer look at the objectives of economic policy, it generally makes sense to distinguish three levels: the general objectives, so to speak the guidelines of the policy measures, the targets, which are the variables that should be affected by the policy instruments in order to achieve the objectives and the instruments themselves.

When the eastern German transition process was initiated with the foundation of the Economic Union, the economic guidelines under the roof of the social market principle were clearly laid down by the constitutional framework, i.e. the transfer of the western German legal system. In this context, equalising the living standards in both parts of the country and bringing a self-sustaining upswing on the way by building up a competitive economic structure with the industrial base — especially the export base — as a pre-requisite for growth and prosperity are clearly on top of the agenda of the economic policy objectives (JWB 1992).

The variables which are supposed to be tackled in pursuing these objectives can be traced back to several sources: the *Staatsvertrag,* e.g. mentions important variables for building up a competitive eastern German economy, stressing structural change, the creation of modern jobs and a strong basis of small- and medium-sized enterprises (SMEs). The guidelines of German regional policy (Rahmenplan der "Gemeinschaftsaufgabe zur Verbesserung der regionalen Wirtschaftsstruktur"), which benefits the entire area of eastern Germany in the first years of transition, advocate a supply policy supporting structural change, growth and the creation of competitive jobs in order to facilitate a reduction of regional differences in living standards and a self-sustaining upswing (Deutscher Bundestag 1997). Thereby, regional policy as several other policy measures concentrate on the industrial sector as the export base of a region. All in all, the policy targets expressed here seem to fit very well with what was diagnosed as the needs of the eastern German economy.

Figure 1 – The Framework of Objectives of Government Policy in Eastern German Transition: Guidelines, Targets and Instruments



In order to achieve the objectives, one might distinguish four categories of policy instruments: privatisation, introduction of a market economic framework, i.e. the transformation of the legal and institutional system and the set-up of the necessary infrastructure, subsidization of the enterprise sector and, as an instrument of social compensation, the transformation of social security, including consumptive transfers to eastern Germany (Lang 1998). Each of them is meant to tackle the targets structural change, employment and growth, resp. to socially compensate the pains of transformation. The system of objectives and instruments is summarised in Figure 1.

2. Extent of Policy Interventions

Because the eastern German government was nearly bankrupt in 1990 and on top of this faced enormous debts, the costly transformation of the eastern German economy would not have been possible without financial transfers from the west. All in all, western German gross transfers to the east as reported by the German Federal Ministry of Commerce (Bundesministerium für Wirtschaft, BMWi) and the *Deutsche Bundesbank* amounted to almost DM 1.4 trillion from 1991 to 1998 with about two thirds paid by the Federal Government — as transfers to private and public households, expenditures for infrastructure and subsidies to firms. This calculation neither includes the THA-transfers nor revenue shortfalls, e.g. due to tax reductions.

Although subsidies do not represent the quantitatively largest part of transfers from west to east, they will be in the centre of this analysis. The reason is that in talking about economic policy in eastern Germany, subsidization is the instrument most frequently and most vehemently discussed. As a crucial variable in the restructuring process, it has a direct impact on the production side of the economy and — due to the fact that it represents a government intervention which goes beyond the mere establishing of market economic conditions and implies possible side effects and distortions — is certainly more controversial than expenditures for infrastructure. Moreover, the potential for policy modifications is much higher with subsidization than e.g. with social transfers, the latter being to a large extent determined by the German system of social security.[1]

Many "institutions" are involved in giving support to eastern German firms, mainly the Federal Government, the EU, the European Recovery Program (ERP) and the government banking institutions, the eastern German *Länder* and last not least, the THA. In 1999, the catalogue of support programs by Federal Government, ERP, government banks and eastern German *Länder* comprised 402 different programs for eastern Germany. It would certainly not make sense to list and exactly describe all of these programs; only the most important ones shall be considered in detail. The focus will be on investment subsidies granted by the Federal Government and its banking institutions.

Between 1990 and 1998, more than DM 70 billion were given to eastern German firms as financial aid directly by the government and an additional DM 50 billion were granted in the form of tax reductions through extra depreciation allowances (DIW, IfW and IWH 1999). The principal instruments of subsidization of the Federal Government are directed towards investment; worth mentioning are the investment bonus (Investitionszulage), the investment grant for the improvement of regional economic structures (Gemeinschaftsaufgabe "Verbesserung der regionalen Wirtschaftsstruktur") — in terms of subsidy equivalent quantitatively the most important support program — and extra depreciation allowances. The figures on the financial means granted to eastern German firms according to these instruments can be taken from Table 1.

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[1] This does not mean that other variables which are of significant influence on the eastern German economy — like social transfers — will be completely neglected. As far as it seems necessary, their effects will be included in the analysis.

Table 1 – Selected Subsidies to Eastern German Firms, 1990-1998 (Billion DM)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	Total
Bonus	0.00	1.04	4.19	4.89	4.44	3.62	2.41	1.74	1.22	23.55
Grant[a]	0.10	7.00	5.01	5.17	5.40	4.14	6.12	4.59	6.18	43.71
Depr. allowance[b]	0.00	3.40	4.90	6.30	7.10	9.10	8.90	6.02	5.76	51.48
ERP-Programme (ERP-programs)[c]	4.66	8.15	6.12	6.80	6.02	4.10	3.58	3.17	2.90	45.50
KfW-loans[d]	0.38	5.91	6.34	3.73	3.64	2.05	2.14	1.65	1.38	27.22
DtA-loans[e]	0.54	3.52	3.88	3.49	3.14	2.47	2.47	2.07	1.51	23.09

[a]Only commercial enterprises. – [b]Estimated tax reduction. – [c]Including ERP-Existenzgründungsprogramm (ERP-program for newly founded firms), ERP-Modernisierungsprogramm (modernization program), ERP-Aufbauprogramm (ERP-reconstruction program) and ERP-Beteiligungsprogramm (ERP holding program). – [d]Including KfW-Mittelstandsprogramm (KfW-programs for SMEs), KfW-Investitionscreditprogramm (KfW-investment loan program, only 1991-1992) and some other smaller SME programs. – [e]DtA-Existenzgründungsprogramm (DtA-program for newly founded firms) and DtA-Eigenkapitalhilfeprogramme (DtA equity program) including Partnerschaftsprogramm (equity partnership program) and Eigenkapitalergänzungsprogramm (equity supplement program) from 1995 to 1998.

Source: KfW (1991); Bundesamt für Wirtschaft; DIW, IfW and IWH (1999); Sachverständigenrat (1999).

Moreover, eastern German firms have access to loans with reduced interest rates and favourable conditions via the two German government banks, the KfW and the DtA. The means come from the ERP and from the banks themselves. They are distributed in the context of several programs with different intentions and are mainly directed towards SMEs. Most of the loans are intended to help to finance investment, some help to increase equity or to finance holdings. The subsidy equivalent of the subsidized loans consists of the discounted interest rate differential as to market interest rates and eventual other favourable conditions (e.g. years free of discharge). Compared to the investment bonus and grant which are to full extent subsidy equivalent, this is significantly less.

Next to the instruments of investment subsidization described above, there are several tax reductions and subsidy programs which do not favour investment directly, but focus on other aspects. They can be grouped into favourable tax conditions, securities, sales support, support of information and counselling, R&D support and labour market programs, but are — compared to investment subsidies — of minor importance. Thus, they will not be further considered.

3. Effects of Subsidization and Selected Strategic Variables in Eastern German Transition

a. Subsidization

Subsidization reaching an extent as it does in eastern Germany and concentrating in particular on one production factor, namely capital resp. investment, represents a strong intervention in the market allocation mechanism and — together with other variables in the transition process such as consumptive transfers and wages — can be expected to have fundamental effects on economic structures. Regarding the entire production side of subsidized industries and referring to a neo-classical framework, capital subsidies influence economic structures and the allocation of factors via two channels:

- via an output effect: Because the user cost of capital are part of overall production costs, capital subsidies lead to a reduction of production costs. If this reduction of production costs is entirely or partly passed on to product prices, demand increases and firms would want to establish capacities and to increase output. Investment subsidies can be expected to favour relatively fixed-capital-intensive economic structures, i.e. industries which belong in many western industrial countries to the ailing branches, such as iron and steel, textiles or chemicals (except pharmaceuticals).[2] In contrast to industries that use the factor skilled labour intensively, these industries do not fit with the comparative advantage of countries which have a relatively high potential of skilled labour. This is true for western as well as for eastern Germany, the latter having adopted a high-wage-high-skill strategy after unification, which is only sustainable if enough jobs can be created in the high-skill sector.

- via 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 (Buck and Atkins 1976; Asmacher, Schalk and Thoss 1987; Harris 1991; Deitmer 1993).

Without any further assumptions, e.g. on the elasticity of substitution between factors which determines the size of the substitution effect, or on the factor intensity of the subsidized firm or industry, it is not possible to say beforehand which effect will predominate. If one subdivides labour into skilled and unskilled labour, a predominant substitution effect is more likely for unskilled labour because in order to operate new equipment (capital), a firm often needs additional skilled workers.

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[2] This effect can be alleviated by granting investment subsidies only for a limited time. Then the investor has to take into account that if he decides to set up a very capital-intensive establishment, he has to expect high costs of modernising the equipment in the future without receiving subsidies (DIW, IfW and IWH 1999). However, because experience shows that it is politically difficult to abolish subsidies once introduced, it can be assumed that eastern German investors rely on the permanent nature of subsidization.

Regarding the industrial sector and subdividing it into three parts, 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 industrial structures: 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 industries 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, concerning employment, the substitution effect might prevail (Gerling 1998).

Considering this, capital subsidies are from a theoretical point of view only partly in accordance with the objectives of government policy. Even if they are significant enough to induce additional investment, they might miss the targets of bringing on structural change in a direction which is in accordance with eastern Germany's potential comparative advantages — that is relatively high skills of the labour force — and of creating additional competitive jobs. Instead, they might increase capital intensity in production to an extent which makes much more investment necessary in order to employ a given number of people compared to a situation without this kind of subsidy (Sinn and Sinn 1993).

As hypothesised in the theoretical analysis, a — in relation to the western German figures — relatively large share of investment concerned capital-intensive industries[3] (Table 2). This gives reason to worry because it is mainly the skill-intensive industries which promise growth in the future.[4]

Table 2 – Structure of Investment in the Manufacturing Sector in Germany According to Factor Intensities of Industries 1991-1998(Percent)[a]

Sectors	Eastern Germany	Western Germany
Capital-intensive	60	44
Skilled-labour-intensive	26	40
Labour-intensive	14	16

[a]Cumulated gross real investment in establishments of enterprises with 20 and more employees.

Source: Görzig and Noack (1999); own calculations.

Taking a look at the structure of employment, the trend of a development at the expense of skilled-labour-intensive structures is confirmed: in skilled-labour-intensive branches, the employment share fell heavily from 1991 to 1998 as compared to other industries (Table 3). Surprisingly, not capital, but labour-intensive branches faced a strong increase in employment shares. This development might be caused by a few eastern German branches which mainly produce for local markets and/or for the construction sector such as printing, rubber, metal products, plastics and wood processing, which benefited strongly from the eastern German demand conditions after unification and started to boom — a result confirmed by the share of industry output (Table 4).

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[3] For a disaggregation of industries according to factor intensities (labour-, skilled labour- and capital-intensive) see Table A1 in the appendix.

[4] This is proved by figures on production growth of skill-intensive industries, especially machinery and electrical machinery, in highly developed industrialised countries, including western Germany (see e.g. NIW 1997).

Table 3 – Shares in Employment in the Eastern German Manufacturing Sector According to Factor Intensities 1991 and 1998 (Percent)[a]

Sectors	1991	1998	Note: Western German Manufacturing 1998
Capital-intensive	42	40	25
Labour-intensive	10	25	22
Skilled-labour-intensive	48	35	53

[a]Establishments of enterprises with 20 and more employees.

Source: Görzig and Noack (1999); own calculations.

Table 4 – Shares in Real Output in the Eastern German Manufacturing Sector According to Factor Intensities 1991 and 1998 (Percent)[a]

Sectors	1991	1998	Note: Western German Manufacturing 1998
Capital intensive	48	46	34
Labour intensive	13	24	19
Skilled-labour-intensive	39	30	47

[a]Establishments of enterprises with 20 and more employees.

Source: Görzig and Noack (1999); own calculations.

Turning from economic structures towards employment as a whole, it has to be stated that obviously more labour and skilled labour have been shed than have been absorbed anywhere else in eastern German transition so far. If this, together with the direction of structural change, can be partly assigned to investment subsidization, then this instrument of government policy has seriously missed its aims.

Regarding productivity increases does not make the picture any brighter because they are rather disappointing against the background of the enormous investments. Certainly, in the first years of transition output per worker rose rapidly. This, however, was mainly due to the massive cuts in overemployment, a process which is more or less coming to an end. As a consequence, the rise in productivity slowed down with the progress of transition. Only recently, an upwards trend is visible.

b. Other Strategic Variables

Subsidization as a part of economic policy stands in the context of many variables influencing economic structures in eastern German transition and cannot be regarded in an isolated way. Several variables — some also part of economic policy, others more or less outside the reach government action — interfere with them, either in a positive or in a negative, counteracting way. Two of them, which are characteristic of the transition process, namely wage policy and the enormous consumptive transfers from the west as social compensation, shall be considered here in detail and examined as to their interaction with investment subsidies to eastern German firms.

Wages and the Labour Market

From 1991 up to now, gross monthly earnings in the producing sector in eastern Germany have roughly doubled and came to reach about 75 percent of the western German level. In eastern German manufacturing, labour costs reached on average about 70 percent of the western German level in 1997 with some skilled-labour-intensive industries standing in tough international competition (in particular machinery and electrical engineering) at the top of the list (Gerling and Schmidt 1997). This is a particularly serious problem because productivity is lagging behind: Despite heavy capital investment, it hardly exceeded 60 percent of western German productivity.

Rising wages contribute to a change in relative factor prices in favour of the factor capital and make it even more likely that the net effects on the labour market are strongly negative and that especially those branches are hit which use the factor labour or skilled labour intensively. Added to this, the heavy overmanning of most eastern German firms and the crashing sales after unification increased the pressure on employment. Looking at the data, the consequences are more than obvious: in 1998, there were not even two thirds of the about 10 million persons left who were gainfully employed in the whole GDR economy; 1.4 million people were unemployed, corresponding to a rate of unemployment of 18 percent, which was twice as high as in the west. The situation was especially grave in the eastern German industrial sector where the reduction of employment exceeded the average.

Consumptive Transfers and Compensations

Considering the extent of social transfers to eastern Germany, it must be assumed that these transfers had a deep impact on demand conditions and via this channel, also on the production side of the eastern German economy. Here, they are under suspicion of having reinforced the concentration on the production of non-tradeable (comprising in particular many services and goods and services from the construction sector). Because such a concentration of production contradicts a competitive, export-oriented industrial structure as a basis for long-term employment and growth, the large amounts of social transfers might have worked against the government's policy objectives.

The government of the GDR had for a long time directed the consumptive behaviour of the population by centrally determining the price structure. The aim was to prevent people from consuming certain types of goods which were considered as luxury according to the socialist point of view. As a consequence, after unification, eastern Germans had a pent-up demand for consumption goods. This demand together with the demand for construction raised by the desolate state of large parts of buildings and infrastructure was certainly fostered by rising wages and by the transfers given to eastern Germany for consumptive purpose. As demand exceeded production in most cases, two things increased: imports of traded goods and prices of non-tradeable goods, among them construction. Risen prices make production in this field relatively more profitable. This gives reason to believe that consumptive transfers indeed contributed to directing the eastern German economy towards concentrating on the production of non-tradeable goods or those goods which are related to the production of non-tradeable goods (Gerling 1998). Similar phenomena, usually caused by a resource boom in the economy instead of transfer payments, are known as "Dutch Disease" scenarios.[5]

Presumably, the strengthening of the non-tradeable sector made even more subsidization to the industries necessary than was necessary anyway in order to increase the incentives for investors to engage in industrial production. Furthermore, it becomes more and more obvious that the boom in the non-tradeable sector was of a temporary kind because it was mainly led by construction. As

[5] Detailed analyzes of "Dutch-Disease" phenomena can e.g. be found in McKinnon (1976); Bruno and Sachs (1982); Corden (1982); Enders and Herberg (1983) and van Long (1984).

such, it cannot provide competitive jobs which might absorb those parts of the labour force which are set free in the process of economic restructuring.[6]

III. A Theoretical Model to Analyze the Impact of Investment Subsidies on Factor Demand and Production in Eastern Germany

In this chapter, a model to test the outcome of output and substitution effects of changes in the factor price relations in eastern Germany will be set up. The model is based on analyzes by Faini and Schiantarelli (1985), Asmacher, Schalk and Thoss (1987), Deitmer (1993) and Schalk and Untiedt (1996), which are extended and suited to the conditions in the eastern German economy.

1. Factor Demand and Substitution

Starting point of the model is a simple production function of the CES type. Three factors of production are meant to be included in the analysis, namely capital (K) and two aggregates of labour, skilled (SL) and unskilled (L). Although empirical studies which disaggregate labour according to skill levels are rare such a disaggregation makes sense because the effects of changes in factor price relations on factor demand can be expected to be co-determined by the skill level of labour. It may be argued, e.g., that unskilled labour can more easily be replaced by machinery, whereas skilled labour is often needed to manage the

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[6] It would be more promising if the emphasis in the sector which is here labelled "non-tradeables" would lie on production-related services — a branch which is getting stronger and stronger in western Germany and in many other western countries. However, a development of this branch in eastern Germany would require a stronger industrial sector — so here the cat bites its own tail!

machinery and thus might even be complementary to capital (Layard and Walters 1978; Broer and Jansen 1989).

The problem of assuming the same substitution elasticity between all factors can be avoided by designing a multi-level CES function, "nesting" together factors of production for which the same s is assumed in a subaggregate input. Firms then decide about their factor demand separately on the different stages of nesting (Sato 1967; Layard and Walters 1978; Prywes 1981). In the general case of three factors of production z_i, $i = 1,2,3$ the two stages of the production function would look as follows:

$$Q = A(t)\left[d_1 z_1^{-r} + (1-d_1) Q_{sub}^{-r}\right]^{-\frac{n}{r}} \tag{1}$$

$$Q_{sub} = \left[d_2 z_2^{-r_{sub}} + (1-d_2) z_3^{-r_{sub}}\right]^{-\frac{1}{r_{sub}}} \tag{2}$$

with Q representing output, d_1, d_2 representing variable distribution parameters, $r = \frac{1-s}{s}$, $r_{sub} = \frac{1-s_{sub}}{s_{sub}}$ and n representing the parameter of homogeneity (inverse of scale elasticity) and $A(t)$ representing technical efficiency. The subscript sub indicates the first stage. Prerequisite for this kind of modelling is that the substitution elasticity of each of the factors in the nest as well as of the nest as a whole with the factor outside the nest is the same (Berndt and Christensen 1973; Sheinin 1980).

The concept of a two-stage CES function offers several alternatives of nesting the production factors, each alternative representing a different structure of the production process and implying different elasticities of substitution (Sheinin 1980). In the case of the three factors of production K, L and SL, the subaggregate input Q_{sub} might either contain K and L, K and SL or L and SL. If one follows the hypothesis of easier substitutability between capital and unskilled labour, the first two of these groupings are most plausible. Here, the first grouping was chosen because it produced the most plausible results.

From a production function as presented above, it is possible to derive a firm's factor demand under two different behavioural assumptions: first, it can be assumed that firms maximise their profits. Optimality conditions express 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-utilised capacities (Berndt 1981; Asmacher, Schalk and Thoss 1987). Moreover, the model only works with decreasing returns to scale.[7]

Second, in order to avoid the restrictions on market conditions and on returns to scale, it can be assumed that firms minimise their costs on each of the two stages of the production function. On the first stage, this gives

$$\min cK + wlL \tag{3}$$

subject to $$\overline{Q}_{sub} \leq \left[d_2 K^{-r_{sub}} + (1-d_2) L^{-r_{sub}}\right]^{-\frac{1}{r_{sub}}} \tag{4}$$

On the second stage, we get

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[7] 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).

$$\min wslSL + p_{Q_{sub}} Q_{sub} \tag{5}$$

subject to $\overline{Q} \leq A(t)\left[d_1 SL^{-r} + (1-d_1)Q^{-r}\right]^{-\frac{n}{r}}$ (6)

From this two-stage optimisation, under the assumption of output being exogenous and cost-decreasing neutral technical progress of $B = B_0 e^{-lt}$, the demand for the three factors of production K, L and SL can be derived using the first order conditions (see Appendix A):

$$K = n^s (1-a_1) a_2 \left(\frac{p_{Q_{sub}}}{p_Q}\right)^{-s} \left(\frac{c}{p_{Q_{sub}}}\right)^{-s_{sub}} Q^d B e^{lt(s-1)+l_{sub}t(s_{sub}-1)} \tag{7}$$

$$L = n^s (1-d)^s (1-a)^{s_{sub}} \left(\frac{p_{Q_{sub}}}{p_Q}\right)^{-s} \left(\frac{wl}{p_{Q_{sub}}}\right)^{-s_{sub}} Q^d B e^{lt(s-1)+l_{sub}t(s_{sub}-1)} \tag{8}$$

with $s = 1/(1+r)$ and $d = \frac{1-s+ns}{n}$ and $l_{sub}(s_{sub}-1)$ measuring technical progress due to capital/unskilled labour substitution, next to $l(s-1)$ measuring technical progress due to skilled labour substitution (Hansen 1993).

$$SL = n^s d^s \left(\frac{wsl}{p_Q}\right)^{-s} Q^d B e^{lt(s-1)} \tag{9}$$

(Sheinin 1980; Hansen 1993). By log-linearising the factor demand equations 7 to 9 we obtain

$$\ln K = const - s_{sub} \ln\left(\frac{c}{p_{Q_{sub}}}\right) - s \ln\left(\frac{p_{Q_{sub}}}{p_Q}\right) + d \ln Q + \left[(s-1)l + (s_{sub}-1)l_{sub}\right]t \tag{10}$$

$$\ln L = const - s_{sub} \ln\left(\frac{wl}{p_{Q_{sub}}}\right) - s \ln\left(\frac{p_{Q_{sub}}}{p_Q}\right) + d \ln Q + \left[\left(s - 1\right) l + \left(s_{sub} - 1\right) l_{sub}\right] t \quad (11)$$

$$\ln SL = const - s \ln\left(\frac{wsl}{p_Q}\right) + d \ln Q + \left(s - 1\right) l t \quad (12)$$

which can be used as basis of estimation.

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 maximisation. It is exogenous in the factor demand functions, which allows to model it separately and to consider supply as well as demand side effects. Restrictive assumptions concerning returns to scale are not necessary (Asmacher, Schalk and Thoss 1987). For these reasons, a model based on cost minimisation behaviour is adopted in the following analysis.

As a measure of factor substitution, the symmetric Allen-Uzawa elasticities of substitution (AES) between factors i and j can be computed from the system of factor demand equations derived above. It measures substitution between factors of production under a change in factor price relations when output is held constant (Layard and Walters 1978; Beißinger 1999).

For a two-stage CES function, the second stage substitution elasticity s corresponds exactly to the AES between SL and Q_{sub}:

$$s = s_{SLQ_{sub}} = s_{SLL} = s_{SLK} \quad (13)$$

and measures substitution between SL and the factors on the first stage. Concerning the first stage substitution elasticity s_{sub}, a transformation is necessary in order to obtain the AES between K and L:

$$s_{KL} = s + \frac{1}{(1-s_{SL})}(s_{sub} - s) \tag{14}$$

with s_{SL} being the share of factor SL in total cost (Sato 1967; Sheinin 1980; Prywes 1981; Hansen 1983). Whereas s and s_{sub} have to be zero or positive — otherwise the quasi-concavity of the subfunctions is not assured — s_{KL} might also have a negative sign, implying that the factors are complements and both fall at a rise of either of its factor prices (Layard and Walters 1978).

The "own" elasticities of substitution which do not have any direct economic interpretation can be derived as (Sheinin 1980)

$$s_{KK} = s + \frac{1}{s_{Q_{sub}}}(s_{sub} - s) - \frac{1}{s_K} s_{sub} \tag{15}$$

$$s_{LL} = s + \frac{1}{s_{Q_{sub}}}(s_{sub} - s) - \frac{1}{s_L} s_{sub} \tag{16}$$

$$s_{SLSL} = -\frac{(1-s_{SL})}{s_{SL}} s \tag{17}$$

As the AES is defined as $s_{ij}^A \equiv e_{ij}^* / s_j$ where e_{ij}^* is the output-constant cross elasticity of factor demand, the mere substitution effect (output constant) of a change in the price of factor j on factor i can be expressed as

$$e_{ij}{}^{*} = \frac{\P \ln z_i}{\P \ln p_j}\bigg|_{\overline{Q}} = \frac{\P z_i}{\P p_j}\bigg|_{\overline{Q}} * \frac{p_j}{z_i} = s_{ij}{}^{A} s_j \,, \qquad i, j \in \{K, L, SL\} \text{ and } i \neq j \tag{18}$$

and the output-constant effect of a change in its own factor price as

$$e_{ii}{}^{*} = \frac{\P \ln z_i}{\P \ln p_i}\bigg|_{\overline{Q}} = \frac{\P z_i}{\P p_i}\bigg|_{\overline{Q}} * \frac{p_i}{z_i} = s_{ii}{}^{A} s_i \tag{19}$$

Adding the output effect as

$$e_{ii}{}^{**} = \frac{\P \ln z_i}{\P \ln p_i} = \frac{\P \ln z_i}{\P \ln Q} * \frac{\P \ln Q}{\P \ln p_i} = \frac{\P z_i}{\P p_i} * \frac{p_i}{z_i} \tag{20}$$

yields the total effect of a change in a factor price on a certain factor of production.

2. A Note on the Underlying Technology: Putty-Clay vs. Putty-Putty

In order to better model factor substitutability in the production process, many authors have suggested and empirically tested a putty-clay-approach to production technology (e.g. Bischoff 1971; King 1972; Schiantarelli 1983; Faini and Schiantarelli 1985; Artus and Muet 1990). A putty-clay technology implies that a firm can only choose the factor input relations on newly installed equipment, not on old capital vintages, i.e. factors of production are substitutable only ex ante whereas in the ex-post production function, the coefficients are fixed. Changes in relative factor prices thus lead to changes in factor input not instantaneously as in putty-putty models where factor substitution is possible on all capital vintages, but with a lag (Johansen 1959; Broer 1985; Deitmer 1993; Kuper and Kroonenberg 1993; Schalk and Untiedt 1996).

In the cost function, only those costs are relevant for the production decision of a firm which concern the new capital vintage, i.e. investment:

$$C_t = c_t I_t + wl \int_{v=t-T}^{t} \Delta L_v dv + wsl \int_{v=t-T}^{t} \Delta SL_v dv \tag{21}$$

From this follow, considering cost minimisation conditions, the factor demand equations

$$I_t = g\left(\frac{c}{p_{Q_{sub}\ t}} , \frac{wsl}{p_{Q_{sub}\ t}} , \Delta Q_t , B_{sub}(t) \right) \tag{22}$$

$$\Delta L_t = h\left(\frac{wl}{p_{Q_{sub}\ t}} , \frac{wsl}{p_{Q_{sub}\ t}} , \Delta Q_t , B_{sub}(t) \right) \tag{23}$$

with $\Delta L_t = L_t - (1-d_L)L_{t-1} \quad \Leftrightarrow \quad L_t = (1-d_L)L_{t-1} + \Delta L_t$ (24)

$$\Delta SL_t = g\left(\frac{wsl}{p_{Q\ t}} , \Delta Q_t , B(t) \right) \tag{25}$$

with $\Delta SL_t = SL_t - (1-d_{SL})SL_{t-1} \quad \Leftrightarrow \quad SL_t = (1-d_{SL})SL_{t-1} + \Delta SL_t$ (26)

where d_L, resp. d_{SL} represents the share of workers having worked on scrapped machines.

This system postulates that changes in factor demand depend on the level of relative factor prices (Artus and Muet 1990). Taking its good "intuitive performance" into account, the putty-clay model will be adopted here.

3. 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 optimisation to static optimisation and allows to integrate the various capital subsidies granted by the government to eastern German firms relatively easily (Deitmer 1993).

Applied in a putty-clay framework under the assumption of a cost minimising behaviour of firms, they are derived from minimising the function

$$\int_{t=0}^{T} wl_{t+q}\Delta L_t e^{i(1-u)q} + wsl_{t+q}\Delta SL_t e^{i(1-u)q} + q_t I_t + Tax_t \tag{27}$$

where q is the price of investment goods, Tax represents taxation (taxes minus subsidies), i the interest rate, u the tax rate and T the maximum life of a vintage, subject to the ex-ante production function

$$\Delta Q = f\left(I_t, \Delta L_t, \Delta SL_t\right) \tag{28}$$

If the cost for unskilled and skilled labour are combined as cost of labour in total, w, and firms assume a constant rate of wage growth w, the objective function is given as

$$w_t \frac{1-e^{-(d-w+i(1-u))T}}{d-w+i(1-u)}\Delta\left(L_t + SL_t\right) + q_t I_t + Tax_t \tag{29}$$

and the user cost of capital result as[8]

$$c = \frac{1-s}{1-u}\left[\frac{d-w+i(1-u)}{1-e^{-[d-w+i(1-u)]T}}\right]q_t \tag{30}$$

with s being the subsidy and d being the depreciation rate.

One crucial factor influencing eastern German firms' user cost of capital — which is supposed to be at the core of the analysis — is embodied in the rate s: the instruments of investment subsidization as discussed in section II. 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 up regressing investment figures on investment figures (Asmacher, Schalk and Thoss 1987). For this reason, the second method is chosen.

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8 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 $c_t = 1 - s_{modified}\left[\frac{d-w+i}{1-e^{-[d-w+i]T}}\right]q_t$. Since there is a large share of eastern German firms still operating in the red — in 1991 it was more than 80 percent, in 1998 still around 40 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.

The subsidies considered are the investment bonus, the investment grant, the depreciation allowance and the reduced-interest loans by the government banking institutions.[9] These constitute a major part of subsidization as is proved in the IAB-survey: of 545 firms which did receive some subsidization — being about half of all firms in the survey — 422 claimed bonus and/or depreciation allowance, 165 the grant and 114 loan programs. In total, around 230 firms claimed other support instruments (Müller 2000).

All in all, the government instruments of capital subsidization decreased capital costs in eastern Germany by some 15-30 percent depending on the year and the industry; on average, they amount to DM 4 up to DM 7 per DM 100 of capital in the period under study (see Tables A2 and A3 in the appendix). These figures are quite in line with another estimation by Schalk and Untiedt (1995), who calculate eastern German user cost of capital as DM 5 to DM 7 (differing according to region) for 1992, although these are not estimated according to a putty-clay technology.

4. Modelling Output

In a factor demand model assuming cost minimisation, 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 connec-

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[9] For a discussion of subsidy conditions and subsidy rate calculations see Appendix B.

tion between factor prices and industry output (Gerling 1998). The relevant variable for such an output equation is — in a putty-clay model — the expected output on vintage v, Q_v, being proxied by the actual output on vintage v, ΔQ, which is calculated as total output after installation minus total output before installation plus output on scrapped machines:

$$\Delta Q_t = Q_t - (1-d)Q_{t-1} \tag{31}$$

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 (Schalk and Untiedt 1996):

$$\Delta Q_t = f\left(SC_t, DC_t, A(t)_t, Q_{t-1}\right) \tag{32}$$

Concerning the supply-side conditions SC, the most important factors influencing industrial output in eastern Germany seem to be cost conditions, i.e. real factor costs. Because rising factor prices increase the cost squeeze for firms, they can be expected to influence output in a negative way. Concerning supply- as well as demand-side conditions DC, 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 tradeable, here: industrial and non-tradeable, here: non-industrial goods. A Dutch-Disease scenario is very likely to have contributed to the eastern German industrial sector lagging behind more locally-oriented sectors like construction or services in economic development. Because this scenario was principally caused by income-related demand increases in eastern Germany which resulted in strong price reactions of non-tradeable goods and thus in incentives to engage in the production of these goods, it might be captured by the inclusion of variables such as the production in the non-tradeables (proxy here: construction) sector, which should have a negative impact on industry output, and by the price relation of tradeable to non-tradeable goods, which should have a positive impact. The exact specification of the output equation in the empirical implementation of the model will be further discussed in the following sections.

IV. Empirical Implementation

1. The Data

A consistent dataset with disaggregated industrial data for 31 industries according to the NACE-classification (two-digit level) for eastern and western Germany since 1991 is available from the DIW (Görzig and Noack 1999), the main source of this data being the production statistics of the German Federal Statistical Office for enterprises with 20 or more employees. The time period of this dataset ranges from 1991 to 1998, only comprising yearly data. For the empirical implementation of the theoretical model, two-digit industry-level data for investment, employment, value-added (output), wages and salaries and capital stock (all in prices of 1995) is used.

The differentiation between labour and skilled labour is made according to wage classes which can be taken from the wage structure statistics. Because many empirical studies obtain good results concerning questions of factor substitution when defining all (production) workers ("blue collars") as unskilled labour and only employees ("white collars") as skilled labour (see e.g. Fitzroy and Funke 1995; Diehl 1999), all workers are put into the unskilled labour aggregate next to the employees in the lowest two salary classes who do not need special education for their work. Skilled labour thus consists of employees in salary class II and III of the wage structure classification. Wages and salaries for unskilled and skilled labour are constructed according to the same pattern from the gross monthly salaries of employees and the gross weekly wages of workers according to wage classes. Thus, the definition of skilled labour is rather narrow. A broader definition, however, which included production workers of wage class 1 into the skilled labour aggregate did not produce satisfactory results, i.e. failed to detect a difference between skilled and unskilled labour substitution.

Price level data is taken from the German Federal Statistical Office and always relies on the index of producer prices.

Because the user cost of capital are not reported for eastern Germany, they have to be calculated from their different components as described in section II. As interest rate, the return on fixed-yield securities is chosen which can be taken from the statistics of the Deutsche Bundesbank. For reasons of simplification, the average tax rate is calculated in a very rough way, only considering the German corporation tax (with a rate of 50 percent from 1991 to 1993 and 45 percent from 1994 onwards) and the Gewerbeertragsteuer, a tax levied by the communes (with a fixed rate of 20 percent on corporation tax). Wealth tax and *Solidaritätszuschlag* (solidarity surcharge for eastern Germany) are 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.[10] 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 5 percent for the whole time period under consideration. The expected growth rate of wages is taken to be 10

[10] For a detailed calculation see Lichtblau (1994).

percent which can be regarded as an average of the period 1991-1998. The investment goods price index is calculated from nominal and real investment figures.

Concerning the different instruments of investment subsidization, the rates and conditions were principally taken from information of the German Ministry of Economics. For calculation of the subsidy equivalent of bonus, grant and loans, the shares of equipment investment come from the ifo Institute, the shares of investment of eastern German enterprises according to firm size and ownership status from Köddermann (1996). Because of a lack of more recent data, 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. Moreover, these shares were not calculated for every single industry but only for industry aggregates differentiated according to factor intensity. The shares of investment type (establishment, expansion, rationalisation) according to industries as well as of SMEs having received the grant are obtained from data out of the subsidy statistics from the Bundesamt für Wirtschaft. For the depreciation allowance, the usual depreciation practice is assumed for "normal" depreciation, i.e. degressive with a rate of 30 percent on equipment over 10 years and linear on buildings over 25 years. Shares of firms making profits are estimated from a firm survey made by the DIW and from data from the Deutscher Sparkassen- und Giroverband (DSGV).[11]

[11] Although the shares vary across industries, they had to be assumed to be equal because data available on the industry-level was not sufficient.

From the thus obtained data on factor costs, the costs of "producing" one unit of Q_{sub} and of Q are calculated by means of a first degree Taylor approximation in $s_{sub} = 1$, resp. $s = 1$:

$$\ln p_{Q_{sub}} = a_2 \ln c + (1 - a_2) \ln wl \tag{32}$$

resp.

$$\ln p_Q = a_1 \ln wsl + (1 - a_1) \ln p_{Q_{sub}} \tag{33}$$

For the factor cost shares a_1 and a_2, an average over the time horizon under study is used because these shares have changed significantly in eastern Germany in the transition period.

Additional variables for the output equation are obtained as follows: the index of production in the construction sector is taken directly from the statistics of the Deutsche Bundesbank. Moreover, in order to mirror the influence of a change in the price structure between tradeable and non-tradeable goods, a price index ratio is constructed between the index of prices in each industry and a weighted index of prices in industries with a trade share below average. The trade shares are taken from western German manufacturing because they can be considered to be less distorted and stem from Klodt et al. (1994).

2. The Basic Empirical Model

The equations 10 to 12 and 32 are used as a basis for the empirical implementation of the putty-clay factor demand model. However, some minor approximations have to be made in order to obtain manageable equations. The differences

ΔL_t, ΔSL_t and ΔQ_t are replaced by the measurable variables L_t, SL_t and Q_t according to:

$$L_t = (1 - d_L)L_{t-1} + \Delta L_t \tag{34}$$

$$SL_t = (1 - d_{SL})SL_{t-1} + \Delta SL_t \text{ and} \tag{35}$$

$$Q_t = (1 - d)Q_{t-1} + \Delta Q_t \tag{36}$$

Considering the general logarithmic approximation of equations of the form $\Delta X_t = X_t - (1 - d_x)X_{t-1}$:

$$\ln \Delta X = \ln d_X + \ln X_{t-1} + \left(\frac{1}{d_X}\right)\Delta \ln X \tag{37}$$

the following equations can be derived which will serve as the foundation of the estimated model (see also Schalk and Untiedt 1996):

$$\ln I_t = const - b_{11} \ln\left(\frac{c}{p_{Q_{sub}}}\right)_t - b_{21} \ln\left(\frac{p_{Q_{sub}}}{p_Q}\right)_t + b_{31} \ln Q_{t-1} + b_{41}\Delta \ln Q_t + b_{51}t + b_{61} \ln I_{t-1} + u_{1t} \tag{38}$$

$$\ln L_t = const - b_{12} \ln\left(\frac{wl}{p_{Q_{sub}}}\right)_t - b_{22} \ln\left(\frac{p_{Q_{sub}}}{p_Q}\right)_t + b_{32} \ln Q_{t-1} + b_{42}\Delta \ln Q_t + b_{52}t + b_{62} \ln L_{t-1} + u_{2t} \tag{39}$$

$$\ln SL_t = const - b_{13} \ln\left(\frac{wsl}{p_Q}\right)_t + b_{23} l \ln Q_{t-1} + b_{33}\Delta \ln Q_t + b_{43}t + b_{53} \ln SL_{t-1} + u_{3t} \tag{40}$$

$$\ln Q_t = const - b_{14} \ln wl_t - b_{24} \ln wsl_t - b_{34} \ln c_t + b_{44} t \tag{41}$$

$$+ b_{54} \ln SC_t + b_{64} \ln DC_t + b_{74} \ln Q_{t-1} + u_{4t}$$

with $b_{11} = b_{12} = s_{sub}$; $b_{21} = b_{22} = b_{13} = s$; $b_{32} = (1 - d_L)$; $b_{33} = (1 - d_{SL})$; $b_{74} = (1 - d\ )$; $b_{51} = b_{52} = (s\ - 1) l + (s_{sub} - 1) l_{sub}$; $b_{43} = (s - 1) l$; $b_{61} = (1 - a)$, where a is an adjustment parameter, and u_{1t}, u_{2t}, u_{3t} and u_{4t} being white noise error terms.

When estimating the model, the demand side conditions DC_t are included as separate variables meant to capture the Dutch Disease effect, namely relative prices between tradeable and non-tradeable goods and the index of production in the construction sector as a representative of sectors mainly producing non-tradeable goods.

In the optimisation process of economic agents, it can usually be assumed that adjustment after a shock in an agent's equilibrium is not free of costs. Assuming a quadratic function of adjustment costs such as

$$C_t = g_0 + g_1 (y_t^* - y_t)^2 + g_2 (y_t - y_{t-1})^2 \tag{42}$$

where y_t^* represents the long-run equilibrium value of y_t and g_i is an adjustment parameter, we can derive the partial adjustment model as:

$$y_t - y_{t-1} = l (y_t^* - y_t) \tag{43}$$

with

$$l = \frac{g_1}{g_1 + g_2}; 0 \leq l < 1 \tag{44}$$

in which firms determine y_t in each period so as to approach the long-run desired level. Generalisation of the lag distribution leads to the general adjustment model with rational lag distribution (Hansen 1993):

$$B(L)y_t = A(L)x_t + u_t \tag{45}$$

$$\text{with} \quad Lx_t \equiv x_{t-1} \tag{46}$$

Econometrically, such a lag model can be easily transformed into an error-correction form so that, starting from equations () to (), we arrive at the following estimable ECM:

$$\Delta \ln I_t = const - l \left[\ln I_{t-1} + b_{11} \ln\left(\frac{c}{p_{Q_{sub}}}\right)_{t-1} + b_{21} \ln\left(\frac{p_{Q_{sub}}}{p_Q}\right)_{t-1} - b_{31} \ln Q_{t-1} - b_{51} t_{t-1} \right] \tag{47}$$

$$+\sum_{j=1}^{2} p_{11,j} \Delta \ln I_{t-j} + \sum_{j=0}^{2} p_{21,j} \Delta \ln\left(\frac{c}{p_{Q_{sub}}}\right)_{t-j} + \sum_{j=0}^{2} p_{31,j} \Delta \ln\left(\frac{p_{Q_{sub}}}{p_Q}\right)_{t-j} + \sum_{j=0}^{2} p_{41,j} \Delta \ln Q_{t-j} + u_{1t}$$

$$\Delta \ln L_t = const - d_L \left[\ln L_{t-1} + b_{12} \ln\left(\frac{wl}{p_{Q_{sub}}}\right)_{t-1} + b_{22} \ln\left(\frac{p_{Q_{sub}}}{p_Q}\right)_{t-1} - b_{32} \ln Q_{t-1} - b_{52} t_{t-1} \right] \tag{48}$$

$$+\sum_{j=1}^{2} p_{12,j} \Delta \ln L_{t-j} + \sum_{j=0}^{2} p_{22,j} \Delta \ln\left(\frac{wl}{p_{Q_{sub}}}\right)_{t-j} + \sum_{j=0}^{2} p_{32,j} \Delta \ln\left(\frac{p_{Q_{sub}}}{p_Q}\right)_{t-j} + \sum_{j=0}^{2} p_{42,j} \Delta \ln Q_{t-j} + u_{2t}$$

$$\Delta \ln SL_t = const - d_{SL}\left[\ln SL_{t-1} + b_{13}\ln\left(\frac{wsl}{p_Q}\right)_{t-1} + b_{23}\ln Q_{t-1} - b_{43}t_{t-1}\right] \tag{49}$$

$$+\sum_{j=1}^{2} p_{13,j}\Delta \ln SL_{t-j} + \sum_{j=0}^{2} p_{23,j}\Delta \ln\left(\frac{wsl}{p_Q}\right)_{t-j} + \sum_{j=0}^{2} p_{33}\Delta \ln Q_{t-j} + u_{3t}$$

$$\ln \Delta Q_t = const - d\left[\ln Q_{t-1} + b_{14}{}' \ln\left(\frac{w}{t}\right)_{t-1} + b_{34}{}' \ln\left(\frac{c}{t}\right)_{t-1} - b_{54}\ln SC_{t-1} - b_{64}\ln DC_{t-1}\right] \tag{50}$$

$$+\sum_{j=1}^{2} p_{14,j}\Delta \ln Q_{t-j} + \sum_{j=0}^{2} p_{24,j}\Delta \ln\left(\frac{w}{t}\right)_{t-j} + \sum_{j=0}^{2} p_{34,j}\Delta \ln\left(\frac{c}{t}\right)_{t-j}$$

$$+\sum_{j=0}^{2} p_{44,j}\Delta \ln SC_{t-j} + \sum_{j=0}^{2} p_{54,j}\Delta \ln DC_{t-j} + u_{4t}$$

which 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 analysis. The adjustment coefficients d_L, d_{SL} and d happen to correspond to the depreciation rates of labour and output (Schalk and Untiedt 1996). From the parameters it is obvious that it is sufficient to estimate two of the three factor demand equations in order to obtain all the coefficients. Here, the investment equation is dropped.[12]

[12] In the literature, it is sometimes stressed that in an investment equation as compared to employment equations, decisions over a longer time-horizon matter so that putting investment and employment together in a joint context may disturb the results (Hazledine 1981). Besides, investment might be influenced by a few large investors in certain years and thus reflect selective developments instead of stable tendencies.

Compared to the basic model, two slight modifications of the variables have been imposed on the output equation: First, the ratios of factor prices and technical efficiency, i.e. factor costs in efficiency units, are taken as explaining variables (Schalk and Untiedt 1996). Second, the two wages variables wl and wsl are put together into one single variable w which represents overall wages in eastern German industries. This is done in order to avoid severe multicollinearity as both wage variables were subject to similar developments.

In order to account for the chosen CES technology of production, several restrictions concerning output and factor price elasticities have to be imposed on the factor demand equations so that it is necessary to regard the factor demand equations as a system and to estimate them interdependently with simultaneous equation methods. In this manner, one does also take account of possible cross-equation correlations of the error terms which are very likely to exist across factor demand equations (Berndt 1991).

3. Pooling the Data Across Industries: The Merits and Drawbacks of Panel Estimation

In order to be able to differentiate factor price impact in different industries and to make a statement about structural effects as to factor intensities, the branches of the industrial sector in eastern German were grouped according to factor intensities for estimation of the model. 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. The results of the classification can be seen in Table A1 in the appendix 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. Because the time series available for eastern German industries only range from 1991 to 1998 and thus do not offer sufficient observations, the data is pooled over the industry dimension so that the model is estimated for three industry panels. Such a panel estimation involves several important methodical issues which have to be considered.

a. Panel Heterogeneity

The first thing one has to account for is the likely heterogeneity of the data panel used for estimation. Estimating a panel data model with simple OLS would imply that all parameters — slopes and intercepts — stay constant over time and across pool-members, which might lead to biased estimates if these assumptions are not met (Hsiao 1986; Baltagi 1995). Especially the latter assumption does not seem very convincing in a context of industries which — although subdivided into groups according to their factor intensities — can still be expected to be characterised by some unobserved variables which vary from industry to industry, such as managerial ability or organizational structure. Unobserved variables which are not the same for each individual in the panel basically correspond to individual constants or dummy variables. A model including these dummy variables has the following general structure (see e.g. Chamberlain 1984; Hsiao 1986; Balestra 1996):

$$y_{it} = dz_i + bx_{it} + u_{it}, \qquad i = 1,\ldots,N \tag{51}$$

$$t = 1,\ldots,T$$

N being the number of cross sections, T the number of time periods.

The error term u_{it} can then be expressed as

$$u_{it} = a_i + e_{it} \tag{52}$$

with a_i as the individual effect and

$$E\{a_i\} = 0 \tag{53}$$

$$E\{a_i a_j\} = \begin{cases} s^2 & i = j \\ 0 & i \neq j \end{cases} \tag{54}$$

resp.

$$E\{e_{it}\} = 0 \tag{55}$$

$$E\{e_{it} e_{js}\} = \begin{cases} s^2_{e,it} & i = j, t = s \\ 0 & other \end{cases} \tag{56}$$

$$E\{e_{it} e_{js}\} = \begin{cases} s^2_{e} & i = j, t = s \\ 0 & other \end{cases} \tag{57}$$

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. The difference between the two is that the assumption of fixed effects implies a correlation of the effects with the explanatory variables, i.e. $E\{x_{it}a_i\} \neq 0$, whereas the assumption of random effects forbids such a correlation, i.e. $E\{x_{it}a_i\} = 0$. Because the model is dynamic in nature, i.e. it contains a lagged endogenous variable with which the individual effects correlate ex definitione (Janz 1997), a random-effects estimation would fail to be consistent so that fixed effects will be included as dummy variables.[13]

b. Unit Roots and Cointegration

For "classical" regression methods, the stationarity of the variables included in the model is an important pre-requisite for having a stable equilibrium. A variable following a stationary process, i.e. being integrated of order 0 (I(0)), does not exhibit any trend-variation. In order to find out the order of integration of variables in panel data models, several testing procedures have been proposed in econometric literature in recent years.[14] In their pioneering study, Levin and Lin (1992) constructed a Dickey-Fuller test which allows for different panel specifications (among others: fixed effects) and is very suitable for a sample of the size as used in this model because critical values for different specifications of N and T are reported, thus considering specific finite sample properties. In order to control for serial correlation in the error term, the test may be augmented by the lagged differences of the endogenous variable as in the usual augmented Dickey-Fuller (ADF) test.

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[13] Another method would be to demean the variables in the model. Both methods then apply OLS.

[14] For a comprehensive overview over unit root and cointegration tests for panel data see e.g. McCoskey and Kao (1997), Banerjee (1999) and Maddala and Wu (1999).

Here, the ADF test will be applied according to the following equation:

$$\Delta y_{it} = (b_1 + b_2 - 1)_i y_{t-1} + d_0 + et + dz_i + n_t + \sum_{j=1}^{q-1} \overline{b}_j \Delta y_{i,t-j} + u_{it} \tag{58}$$

where d_0 is a constant, t a linear common time trend and n_t a time-specific effect which may in practice be concentrated out of the equation. It is obvious that it allows for individual-specific (fixed) effects.

In the test, the null hypothesis $H_0 : (b_1 + b_2 - 1)_i = 0$, i. e. presence of a unit root, is tested against the alternative $H_1 : (b_1 + b_2 - 1)_i = (b_1 + b_2 - 1) < 0$. The results are given in Table 5 for two cases, namely common constant plus trend and fixed effects. All tests are performed on the log-linearised model variables.[15] Due to the short time span under observation, the maximum lag length for the lagged differenced variable chosen is 2.

[15] It has to be noted that only results on those variables are given which appear in the final version of the estimated model.

Table 5 – Results of ADF Tests (Levin and Lin)[a]

Series	Capital-intensive industries		Skilled-labour-intensive industries		Labour-intensive industries	
	I(1), constant and trend					
	t	Lags	t	Lags	t	Lags
ln L	0.52	1	0.03	1	0.40	1
ln SL	1.47	1	-0.99	2	2.28	2
ln Q	-0.42	1	-3.54**	1	3.60	1
ln (wl/p_{Qsub})	-2.12*	0	-0.28	0	-3.06**	0
ln (wsl/p_Q)	0.96	1	-0.49	0	-1.82	0
ln (p_{Qsub}/p_Q)	-1.95(?)	0	-0.59	1	-1.06	1
ln c	-2.94**	0	-2.68**	0	-1.97	2
ln w	-1.99(?)	0	-4.40**	0	-0.49	0
ln (p_t/p_{nt})	-3.08**	0	-4.38**	0	-4.80**	0
ln cons	-2.35*	0	-2.07*	0	-1.92	0
	I(1), fixed effects					
	t	Lags	t	Lags	t	Lags
ln L	-4.73	2	-4.26(?)	2	-1.21	2
ln SL	-3.14	2	-4.68**	1	-10.14**	0
ln Q	-3.67	2	-0.40	2	-2.84	0
ln (wl/p_{Qsub})	-4.08	0	-6.49**	0	-2.75	0
ln (wsl/p_Q)	-3.11	1	-3.00	0	-2.72	0
ln (p_{Qsub}/p_Q)	-2.84	0	-3.07	1	-3.37	0
ln c	-5.88**	0	-3.18	0	-4.91**	0
ln w	-4.50	2	-7.76**	2	-4.19**	2
ln (p_t/p_{nt})	-3.36	0	-3.22	0	-6.19**	0
ln cons	-9.99**	1	-8.81**	1	-8.15**	1

[a]A double (single) asterisk denotes significance at the .05 (.10) level. A question mark indicates that the significance is not quite clear because the critical values given in Levin and Lin (1992) are not reported for the exact specifications of *N* and *T* in this model; thus, they can only be roughly estimated. – [b]ln cons is a one-dimensional variable, i.e. the same for all cross sections so that the Levin/Lin critical values for a common constant apply. These are not as low as those for fixed effects and lie around -1.80 at the .10 level and around -2.20 at the .05 level for panels of this size.

Source: Own calculations.

Although the results produced by the two specifications slightly differ, they agree that most of the model variables are I(1); some variables follow a stationary process.[16]

If we accept the test results of unit roots in some of the series under consideration, we have to make sure that the long run relationships estimated in the model are cointegrated. As unit root analyzes, cointegration in panel data has been widely discussed in the literature in recent years. The intuition behind treating panel data as a special case in cointegration analysis is that first, it has to be taken account of heterogeneity, e.g. in the form of individual-specific intercepts, and second, panel data is often characterised by a short time dimension so that some asymptotic tests like for example the simple t-test proposed by Kremers, Ericsson and Dolado (1992) on the coefficient of the lagged dependent variable are not reliable (see e.g. Breitung and Meyer 1994; Pedroni 1997 and 1999).

A residual-based testing procedure which allows for different degrees of panel heterogeneity (like e.g. heterogeneous deterministic trends and differing cointegrating vectors across the cross sections) is set up by Pedroni (1999). He derives seven test statistics from the cointegrating regressions of the form:

$$y_{it} = dz_i + e_i t + \sum_{k=1}^{K} b_k x_{kit} + u_{it} \qquad (59)$$

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[16] Even if 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).

with K being the number of regressors by performing unit root tests on the residuals:

$$\hat{u}_{it} = r_i \hat{u}_{i,t-1} + \hat{m}_{it} \tag{60}$$

where the slope coefficients in this test are allowed to vary across the cross sections. Four of these statistics are based on estimators which pool the autoregressive coefficient across the cross sections for the tests on the estimated residuals, thus testing the null hypothesis $H_0: r_i = 1$ for all i against $H_1: r_i = r < 1$ for all i. The other three are based on estimators which average the individually estimated coefficients across all cross sections, thus testing $H_0: r_i = 1$ for all i against $H_1: r_i < 1$ for all i (Pedroni 1999). According to Pedroni's nomenclature, the former will be referred to as panel cointegration statistics, the latter as group mean panel cointegration statistics. The different statistics are presented in some more detail in Appendix C. Under certain assumptions and following an appropriate standardisation, all of them asymptotically underlie a standard normal distribution. Under the alternative hypothesis, the panel v-statistic diverges to positive infinity; all other statistics diverge to negative infinity. For small sample sizes as in this analysis, Pedroni (1997) finds that the size distortions are generally relatively small, except for the panel v-statistic which occasionally has very small empirical sizes and the group ADF statistic which has larger empirical sizes than the others. In terms of power, the panel v-statistic and the group rho statistic are found to do rather poorly, whereas the group ADF statistic performed best.

Table 6 – Results of the Cointegration Tests (Pedroni)[a]

Statistics	Unskilled labour demand	Skilled labour demand	Output
	Capital-intensive industries		
Panel v	1.88*	-0.92	4.66*
Panel rho	3.09	2.79	3.81
Panel t	-6.11*	-2.68*	-5.64*
Panel ADF	-13.92*	-5.20*	-17.26*
Group rho	4.00	3.59	5.14
Group t	-7.02*	-6.39*	-8.76*
Group ADF	-60.36*	-75.23*	-46.45*
	Skilled-labour-intensive industries		
Panel v	0.01	1.17	-0.09
Panel rho	2.63	2.10	2.69
Panel t	-6.06*	-2.48*	-5.76*
Panel ADF	-26.65*	-8.06*	-18.75*
Group rho	3.67	3.42	3.83
Group t	-6.94*	-1.93*	-6.37*
Group ADF	-191.97*	-64.87*	-108.82*
	Labour-intensive industries		
Panel v	0.56	-0.57	29.72*
Panel rho	2.61	1.96	2.44
Panel t	-4.44*	-2.19*	-10.70*
Panel ADF	-14.81*	-3.61*	-9.52*
Group rho	3.26	2.94	4.08
Group t	-7.62*	-2.14*	-10.31*
Group ADF	-45.52*	-9.92*	-51.53*

[a]Maximum number of lags included is 2. Tests allow for heterogeneous trends across cross sections. An asterisk denotes significance at the .05 level.

Source: Own calculations.

In Table 6, the results of the seven tests applied to the model equations for unskilled and skilled labour demand and for output are reported for different industries. Although the statistics come to divergent conclusions as to cointegration — possibly due to their different performance in small samples — it is obvious that the majority of statistics is in fact significant and thus rejects the null hypothesis.

c. Dynamic Models and Small Sample Bias

In a dynamic model such as an ECM where a lagged endogenous variable is included, a fixed effects specification which is estimated with a least squares dummy variable estimator (LSDV) might be inconsistent because the error term which considers the fixed effects is correlated with the lagged endogenous variable. The correlation only vanishes if $T \to \infty$ in the stationary case; in the case of a unit root, it does not vanish (Nickell 1981; Sevestre and Trognon 1983 and 1996; Hsiao 1986; Breitung 1992).

Because the model under study is a dynamic one with fixed effects and clearly suffers from a small T, something is to be done about the problem. Several methods have been proposed in order to get rid of the estimator bias known as the "Nickell-bias" (see e. g. Anderson and Hsiao 1982; Arellano and Bond 1991). Here, a corrected LSDV estimator developed by Hansen (1999) will be applied which has proved to be quite promising in terms of its performance in small samples even in the near-unit-root-case of $a = 0.99$. Hansen directly uses the formulas for the Nickell-bias in order to derive a correction.[17] A drawback of the Hansen-bias-correction is that it is only defined for single equations. Thus, in this model, the corrections have to be derived from estimating the single factor demand equations. They are then applied on the estimated parameters of the simultaneous equation system; after that, the cross-equation restrictions are imposed on the corrected parameters. It is assumed that this method is still the best to obtain unbiased results from an efficient estimation because the estimated parameters from the simultaneous equations do not differ substantially from

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[17] For details see Nickell (1981) and Hansen (1999).

those coming from the single equations. Thus, the bias and its correction should not differ substantially either.

4. Estimation Results

The factor demand equations (unskilled and skilled labour) are estimated by means of the RATS econometric software, using the instruction SUR which performs a joint generalised least squares (GLS) estimation on the ECM equations. A c^{2}-test for the validity of the cross-equation restrictions, which reflect the CES-technology, yielded significance levels of 0.97 percent in the case of the capital-intensive industries, 0.79 percent in the case of the skilled labour-intensive industries and 0.01 percent in the case of the labour-intensive industries. Despite the fact that the CES-technology does not seem to be valid in the labour-intensive industries, it is still assumed in all cases here because, as Faini and Schiantarelli (1985) argue, it is very likely that the technology holds on the level of a single firm even if the restriction fails to be valid on an aggregated level (see also Gerling 1998). Moreover, since the results of the restricted equations do not heavily contradict the results of the unrestricted ones, the data does not appear to be essentially violated. The output equation is estimated using the instruction LINREG which performs OLS on the equations and correcting for the Nickell-bias.

The estimation results are presented in Tables A4-A6, the corrections of the coefficients in Tables A7-A9 in the appendix.[18] The coefficients of the parameters of the long-run relationship are estimated directly from the Bewley transformation of the ECM. The estimation range is 1991-1998. In order to confront arguments that an inclusion of the year 1991 might disturb the results because of very strong transition effects causing rapid and radical structural changes, an attempt was made to estimate the equations from 1992 onwards. Because the direction of the results mainly did not change and because the quality of the estimation outcome was in some respects worsened, the study will concentrate on the 1991-1998 results — with the exception of output in the skilled-labour-intensive industries. Here, an estimation from 1992 to 1998 avoids the problem of an adverse output effect of capital costs, but does not alter the other coefficients much. Thus, the reduced estimation range is preferred in this case.

In order to test for heteroscedasticity, a Breusch-Pagan (BP) test (Breusch and Pagan 1979) is performed on the single and on the simultaneous equations (excluding bias-correction) of factor demand as well as on the output equations.

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[18] It should be noted that the dummy variables representing the industry-specific effects are not reported here for the sake of simplification. Since they contain unobservable factors affecting the heterogeneity of the industry panels, they are difficult to interpret and thus not very interesting.

The significance level of the statistic is presented together with the estimation results.[19]

Coming to the interpretation of the estimation results, the focus will lie on the long-run relationship. The short-run coefficients will be ignored here because short-run processes in economic activity often follow a rationale which is difficult to capture. Looking first at the adjustment coefficients, a stable error-correction process towards a long-run equilibrium can be observed in all cases because all coefficients are significant and have a negative sign. It has to be noted, though, that in order to produce a stable output equation for the skilled-labour-intensive industries, the construction variable had to be completely left out of the estimation. Since it was clearly insignificant in the long run as well as in the short run, this proceeding seems legitimate. The output depreciation (or scrapping) rate which corresponds to the adjustment coefficient in the output equations is highest in the capital- and skilled-labour-intensive industries with more than 30 percent and lowest in the labour-intensive industries with 24 percent — figures which are above the value of 9 percent which was found by Schalk and Untiedt

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[19] Although estimating a model in logs diminishes the risk of running into heteroscedasticity problems, two equations obviously still fail to be homoscedastic, namely the demand for unskilled labour (only simultaneous equation) and output in the capital-intensive industries. Heteroscedasticity does not interfere with the fact that the estimation results are unbiased, but it does interfere with their efficiency, i.e. asymptotic normality, so that the t-statistics cannot be interpreted as usual (see e.g. Gujarati 1988). As to output, an estimation which computes a consistent covariance matrix allowing for heteroscedasticity with the option ROBUSTERRORS in RATS did not point to strongly different results concerning significance; this estimation, however, only works without bias-correction so that it is not reported in detail here. As to the demand for unskilled labour in the capital-intensive industries, a ROBUSTERRORS estimation does not work in a simultaneous equation model. Since the t-statistics in this equation are quite unambiguous though, their significance should not change even in the case of a robust estimation.

(1996) for western Germany. This result is not surprising if one considers the degree to which production capacities in eastern Germany became obsolete after unification. Another interpretation of the output scrapping rate concerns the time after which adjustment to the desired output level is achieved. In the capital- and skilled-labour-intensive industries, the mean lag lies around 2, meaning that after two years, 50 percent of the disequilibrium between actual and desired output is reached; in the labour-intensive industries, this mean lag lies between 2 and 3.

The shares of workers having worked on scrapped machines, which correspond to the adjustment coefficients in the labour demand equations, is much higher than the scrapping rate. 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 concerning unskilled labour seems to be relatively fast, of skilled labour relatively slow. The latter result might be caused by stricter rules by the Treuhand for privatised 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") (Gerling 1998).

Taking a first look at the estimated equations, it shows that the output coefficients in the factor demand equations are all below one. They indicate increasing returns to scale ($n > 1$), a result generally not unusual for the industrial sector (see e.g. Fitzroy and Funke 1998).

The results concerning technical progress vary quite a bit between industries and type of labour demand. In the capital-intensive industries, the rates of technical efficiency can be computed as $l = \frac{-0.04}{0.30-1} = 0.06$ and $l_{sub} = \frac{0-0.06(0.30-1)}{0.60-1} = -0.10$, the latter being amazingly negative which implies negative technical progress due to capital/labour subsidization. The reason could be that technical progress is already absorbed in the factor substitution parameters, which is intuitively plausible as technical progress and substitution are always interlinked. Thus, there is no negative effect on unskilled labour from technical progress so that l_{sub} algebraically has to be negative to compensate positive l. In the skilled-labour- and in the labour-intensive industries, l is zero if the insignificance of the trend coefficient is taken into account. In the former industries, $l_{sub} = \frac{-0.06-(0.00-1)*(0.00)}{0.31-1} \approx 0.09$, yielding a rather high rate of technical progress due to substitution between capital and unskilled labour, which seems quite reasonable in the light of transition; in the latter, $l_{sub} = \frac{-0.07-(0.67-1)*(0.00)}{0.83-1} = 0.41$, which appears a bit too high even for a transition process.

For a further analysis of the estimation outcome, it is necessary to transform the raw coefficients into interpretable economic variables which allow to quantify substitution effects, output effects and total effects. Because the model is estimated in logs, the variables can be interpreted as elasticities. An overview over these variables resulting from the estimations is given in Tables 7 to 9; the crude AES on the two stages of production, $s_{SLL} = s_{SLI}$ and s_{IL}, are presented in Table A10 in the appendix. First of all, they do not confirm a Cobb-Douglas production technology because they all prove to be significantly different from one. Second, they indicate that — as expected — substitution is strong between investment and unskilled labour with a substitution elasticity on average around 0.8. Substitution is generally weaker between skilled labour and the investment/

unskilled labour aggregate, in the skilled-labour-intensive industries it is even zero.

Table 7 – Substitution Effects, Output Effects, Total Effects and Productivity Effects in Eastern German Capital-Intensive Industries

	Investment demand	Unskilled-labour demand	Skilled-labour demand
Long-run factor price elasticities e_{ij}^{*} resp. e_{ii}^{*} (substitution effects)	$e_{IL}^{*} = 0.21$ $e_{ISL}^{*} = 0.15$ $e_{II}^{*} = –0.36$	$e_{LI}^{*} = 0.24$ $e_{LSL}^{*} = 0.15$ $e_{LL}^{*} = –0.39$	$e_{SLI}^{*} = 0.08$ $e_{SLL}^{*} = 0.07$ $e_{SLSL}^{*} = –0.15$
Long-run output elasticities e_{ii}^{**} (output effects)[a]	$e_{i(L+SL)}^{**} = 0.00$ $e_{iI}^{**} = –0.42$ $e_{i(p_T/p_{NT})}^{**} = 0.00$ $e_{icons}^{**} = 0.00$		
Total effects e_{ij} resp. e_{ii} (substitution plus output)	$e_{I(L+SL)} = 0.36$ $e_{II} = –0.78$ $e_{I(p_T/p_{NT})} = 0.00$ $e_{Icons} = 0.00$	$e_{LI} = –0.18$ $e_{L(L+SL)} = –0.24$ $e_{L(p_T/p_{NT})} = 0.00$ $e_{LIcons} = 0.00$	$e_{SLI} = –0.34$ $e_{SL(L+SL)} = –0.08$ $e_{SL(p_T/p_{NT})} = 0.00$ $e_{SLicons} = 0.00$
Productivity effects $eprod_{ij} = \frac{¶ \ln Q}{¶ \ln p_j} - e_{ij}$	.	$eprod_{LI} = –0.80$ $eprod_{L(L+SL)} = 0.24$ $eprod_{L(p_T/p_{NT})} = 0.00$ $eprod_{LIcons} = 0.00$	$eprod_{SLI} = –0.64$ $eprod_{SL(L+SL)} = 0.08$ $eprod_{SL(p_T/p_{NT})} = 0.00$ $eprod_{SLIcons} = 0.00$

[a]As factor prices are included in efficiency units in the model, the output elasticity concerning technical efficiency equals the negative sum of the output elasticities concerning factor prices.

Source: Own calculations.

Table 8 – Substitution Effects, Output Effects, Total Effects and Productivity Effects in Eastern German Skilled-Labour-Intensive Industries

	Investment demand	Unskilled-labour demand	Skilled-labour demand
Long-run factor price elasticities e_{ij}^{*} resp. e_{ii}^{*} (substitution effects)	$e_{IL}^{*} = 0.23$ $e_{ISL}^{*} = 0.00$ $e_{II}^{*} = -0.23$	$e_{LI}^{*} = 0.08$ $e_{LSL}^{*} = 0.00$ $e_{LL}^{*} = -0.08$	$e_{SLI}^{*} = 0.00$ $e_{SLL}^{*} = 0.00$ $e_{SLSL}^{*} = 0.00$
Long-run output elasticities e_{ii}^{**} (output effects)[a]	$e_{i(L+SL)}^{**} = -0.39$ $e_{iI}^{**} = 0.00$ $e_{i(p_T/p_{NT})}^{**} = -2.05$		
Total effects e_{ij} resp. e_{ii} (substitution plus output)	$e_{I(L+SL)} = -0.16$ $e_{II} = -0.23$ $e_{I(p_T/p_{NT})} = -2.05$	$e_{LI} = 0.08$ $e_{L(L+SL)} = -0.47$ $e_{L(p_T/p_{NT})} = -2.05$	$e_{SLI} = 0.00$ $e_{SL(L+SL)} = -0.39$ $e_{SL(p_T/p_{NT})} = -2.05$
Productivity effects $eprod_{ij} = \frac{\P \ln Q}{\P \ln p_j} - e_{ij}$	.	$eprod_{LI} = -0.08$ $eprod_{L(L+SL)} = -0.88$ $eprod_{L(p_T/p_{NT})} = -6.35$	$eprod_{SLI} = 0.00$ $eprod_{SL(L+SL)} = -0.97$ $eprod_{SL(p_T/p_{NT})} = -6.35$

[a]As factor prices are included in efficiency units in the model, the output elasticity concerning technical efficiency equals the negative sum of the output elasticities concerning factor prices.

Source: Own calculations.

Table 9 – Substitution Effects, Output Effects, Total Effects and Productivity Effects in Eastern German Labour-Intensive Industries

	Investment demand	Unskilled-labour demand	Skilled-labour demand
Long-run factor price elasticities e_{ij}^{*} resp. e_{ii}^{*} (substitution effects)	$e_{IL}^{*} = 0.33$ $e_{ISL}^{*} = 0.38$ $e_{II}^{*} = -0.72$	$e_{LI}^{*} = 0.11$ $e_{LSL}^{*} = 0.38$ $e_{LL}^{*} = -0.50$	$e_{SLI}^{*} = 0.07$ $e_{SLL}^{*} = 0.21$ $e_{SLSL}^{*} = -0.29$
Long-run output elasticities e_{ii}^{**} (output effects)[a]	$e_{i(L+SL)}^{**} = 0.00$ $e_{iI}^{**} = -1.03$ $e_{i(p_T/p_{NT})}^{**} = 0.00$ $e_{icons}^{**} = 0.00$		
Total effects e_{ij} resp. e_{ii} (substitution plus output)	$e_{I(L+SL)} = 0.71$ $e_{II} = -1.75$ $e_{I(p_T/p_{NT})} = 0.00$ $e_{Icons} = 0.00$	$e_{LI} = -0.92$ $e_{L(L+SL)} = -0.12$ $e_{L(p_T/p_{NT})} = 0.00$ $e_{Lcons} = 0.00$	$e_{SLI} = -0.96$ $e_{SL(L+SL)} = -0.08$ $e_{SL(p_T/p_{NT})} = 0.00$ $e_{SLcons} = 0.00$
Productivity effects $eprod_{ij} = \frac{\partial \ln Q}{\partial \ln p_j} - e_{ij}$	.	$eprod_{LI} = -0.43$ $eprod_{L(L+SL)} = 0.12$ $eprod_{L(p_T/p_{NT})} = 0.00$ $eprod_{LIcons} = 0.00$	$eprod_{SLI} = -0.39$ $eprod_{SL(L+SL)} = 0.08$ $eprod_{SL(p_T/p_{NT})} = 0.00$ $eprod_{SLIcons} = 0.00$

[a]As factor prices are included in efficiency units in the model, the output elasticity concerning technical efficiency equals the negative sum of the output elasticities concerning factor prices.

Source: Own calculations.

Remembering the crucial questions on which this study is built, the following sections will now examine in more detail what the elasticities presented above mean for structural change and competitiveness, for investment and employment and for productivity and growth in the eastern German economy.

a. *Effects of Investment Subsidies and other Variables on Structural Change and Competitiveness*

In order to analyze the industrial structures which slowly started to establish after the production breakdown in 1990 and to evaluate in which way certain variables have contributed to a development favourable or non-favourable for competitiveness, it is necessary to focus on the crude results of the output equation (Table A6) in the first place. Doing this, an interesting thing is that capital costs do not play the expected role in skilled-labour-intensive production; subsidization did not have any output-enhancing effect here. One reason might be that in these industries, international competition is particularly vehement so that other factors which are more important in terms of competitiveness considerations of firms — like wages, e.g. — blot out the impact of the capital cost variable. What is also surprising about capital costs is that they influence output more strongly in the labour- as compared to the capital-intensive industries, which contradicts theoretical considerations. A fostering of more capital-intensive as compared to labour-intensive production by means of investment subsidies cannot be attested. A reason might be the large share of SMEs in the labour-intensive branches for which capital costs are somewhat more important than for larger firms where they are only a small part of a huge set of important variables in the output decisions. Moreover, investors in labour-intensive branches are to a large extent locally oriented and were thus confronted with relatively good production conditions in the transition process. Investment subsidies fell on extremely fertile grounds here anyway and thus were more prone to enhance output than in industries where the struggle for surviving was more fierce and the subsidies were only a drop in the ocean. As such, the effect of capital costs in the output equation might partly mirror some positive Dutch Disease effects which are not adequately reflected by those variables actually meant as Dutch Disease proxies. These positive effects of local-market production might also be responsible for the rising output share that labour-intensive industries report as compared to others (see section II).

Using the capital cost elasticities on output and the reduction of capital costs due to subsidization (Table A3), it is now possible to calculate the yearly and total effects of the investment subsidies on output. Of course, they are positive in the capital- and in the labour-intensive industries; altogether, production in these two industry aggregates would have been by more than DM 4 billion lower each year without the subsidies (Table 10).

Table 10 – Effects of Investment Subsidization on Output in the Period 1991-1998 (billion DM)[a]

	Capital-intensive industries	Skilled-labour-intensive industries	Labour-intensive industries
Output change due to subsidization (billion DM)			
yearly average	2.8	0.0	1.6
total period	22.3	0.0	12.8

[a]Calculated with the help of the yearly average capital cost reduction (industries weighted with their capital cost share relative to that of all industries in the same aggregate). Inaccuracies in the figures result from rounding.

Source: Own calculations.

Approaching output from the other side of factor price relations, namely rising wages, evidence shows that they have hampered production immensely in the skilled-labour-intensive industries. This fits very well with the observation of particularly strong production decreases in some of these industries (e.g. machinery) after unification. The size of the wage elasticity of output in the skilled-labour-intensive industries is very high and may well also absorb other aspects of competitiveness which are not explicitly included in the equation, but — due to the high trade share in these traditionally export-oriented branches — are nonetheless important. Qualification of the workforce might be one of these aspects. In the other industry aggregates, wages do not have any significant impact on output. It might well be that wage costs, which should dampen production, conflict with rising incomes, the latter being strongly correlated with wages and thus reflected in the wage variable, too. Remembering what was said about the Dutch Disease, it stands to reason that rising incomes lead to increased demand and enhance production in particular in locally oriented branches, which can be found mainly among the labour-, but also among the capital-intensive ones.

As to Dutch Disease effects, they cannot be considered to be strongly present on the whole as the used proxies the significance of the used proxies is rather poor. The only Dutch-disease-related variable which is worth considering at all is the tradeables/non-tradeables price relation for the skilled-labour-intensive industries, showing the wrong sign though.[20] However, the unexpectedly negative sign is only surprising at first sight. Looking more closely at what is behind this variable, the outcome gains some logic: A falling p_T / p_{NT} -price relation, which might to some extent reflect an absolute fall in the prices for tradeable goods,

[20] Note: The extremely high coefficients of the price relation variable does not appear too strange if one takes into account the small variation this index variable shows during the time span under observation.

increases the chances to export and thus the incentive to produce more; a rising relation has the opposite effect (Gerling 1998). In the skilled-labour-intensive branches, this effect clearly dominates possible Dutch Disease tendencies; in the other industry aggregates, it manages at least to compensate them. Thus, a rising international competitiveness via prices managed to alleviate the breakdown of skilled-labour-intensive production.

A thing which has to be noted in general is the fact that of course, not all of the variation in output can be explained by the variables in the model. This is reflected e.g. by a proposed fall instead of the actual rise in output in most skilled-labour-intensive branches from 1991 to 1998. It is likely that some factors which are very difficult to observe and to capture, like e.g. discretionary policy measures such as interventions by the Treuhandanstalt to save important firms from going bankrupt, are responsible for this explanatory gap. Moreover, the heterogeneity of the branches in an industry aggregate should not be forgotten, which cannot be fully captured by the industry-specific dummies if it does not only apply to the levels but also on the development of a variable. In the skilled-labour-intensive industries where a few important branches like machinery and other vehicles experienced massive production downfalls in the transition period, these branches might dominate the results even if production in other branches has risen.

b. Effects of Investment Subsidies and Wages on Investment and Employment

Looking first at the mere substitution effects of factor price changes, the usually held suspicion of unskilled labour reacting more strongly than skilled labour to own-price increases is confirmed. It cannot be said, though, that capital and skilled labour are completely complementary, but it is clear from the elasticities that they are less substitutable than capital and unskilled labour.[21] However, whereas in the capital- and labour-intensive industries there is a strong tendency to replace unskilled labour and a weaker, but non-negligible one to replace skilled labour, complementarity between the latter factor of production and the capital/labour aggregate can be assumed for the skilled-labour-intensive industries; the factor on which these industries rely predominantly cannot be replaced by another.

Coming to the total effects of changes in capital costs on investment, they lie between 0.2 and -1.7. This is compatible with what Schalk and Untiedt (1996) find for western Germany (roughly -1.4), but on the whole well above of what Müller (2000) finds in his ad-hoc investment model for eastern Germany (around -0.3), the only empirical investment model for eastern Germany so far. Whereas according to Müller's study, DM 1 of investment subsidies leads to DM 2.46 of investment, the ratio here becomes DM 1 to DM 3.12 in the capital-intensive industries, DM 1 to DM 1.15 in the skilled-labour-intensive industries and DM 1

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[21] A similar result was produced by Fitzroy and Funke (1995) for western Germany. The substitution elasticities they found were a bit lower than the ones in this study which is consistent with the situation of overemployment in pre-transition eastern Germany. An overview over empirical studies on capital/skill complementarity can be found in Hammermesh (1993).

to DM 7 in the labour-intensive.[22] These figures can be regarded as a measure for the efficiency of the subsidies. If subsidies of DM 1 induces less than DM 1 of investment, which is the case as soon as the subsidy rate is above the total capital cost elasticity of investment, then parts of the subsidization are simply taken along without leading to additional investment.

Focusing the question which should be of utmost interest for policy makers dealing with subsidization in eastern German transition, namely whether investment subsidies have done anything good concerning employment, the answer is mixed. The positive output effect of the subsidies clearly dominates the substitution effect, except in the skilled-labour-intensive industries. Overall, the positive impact of investment subsidization is stronger, resp. the negative impact weaker concerning skilled labour because it is substituted less easily.

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[22] These figures can be easily calculated from the total elasticities of investment demand as to its own price (user cost of capital). The term for the elasticity is $\frac{\partial I}{\partial Subsidies}\frac{Subsidies}{I} \equiv e_{II}$ yielding $\frac{\partial I}{\partial Subsidies} = \frac{e_{II}}{(Subsidies / I)}$ with $\frac{Subsidies}{I}$ being the subsidization rate (see also Müller 2000). Usually, one has to differentiate between the potential subsidization rate resulting from the rates of the subsidization instruments and corresponding to the rate by which the subsidies reduce the user cost of capital (see Table A3 in the appendix) and the actual subsidization rate resulting as the ratio between actual given subsidies and investment. Whereas Müller (2000) uses the latter for his calculations, this study has to adopt the former because detailed data on all subsidies given to firms with 20 and more employees in the manufacturing sector, which is the data base of investment here, is not available. Thus, it is assumed that the potential roughly equals the actual subsidization rate, i.e. that the pool of subsidies which is at the firms' disposal is completely used up.

Table 11 – Effects of Investment Subsidization on Investment and Employment in the Period 1991-1998[a]

	Capital-intensive industries	Skilled-labour-intensive industries	Labour-intensive industries
Investment induced by subsidization (billion DM)			
yearly average	1.3	0.2	0.6
total period	10.4	1.2	4.5
Additional jobs due to subsidization, unskilled labour (1,000 persons)			
yearly average	5.2	-2.4	12.0
total period	41.3	-19.3	96.4
Additional jobs due to subsidization, skilled labour (1,000 persons)			
yearly average	13.4	0.0	16.6
total period	106.8	0.0	133.1

[a]Calculated with the help of the yearly average capital cost reduction (industries weighted with their capital cost share relative to that of all industries in the same aggregate). Inaccuracies in the figures result from rounding.

Source: Own calculations.

Table 11 gives an overview over the effects the actual capital cost reduction through investment subsidization had each year on investment and labour demand in eastern Germany from 1991 to 1998. They can be easily obtained from the reduction of capital costs due to subsidization and the estimated total factor elasticities as to capital costs. Overall, about DM 16 billion of investment was induced by subsidization in this period; in the labour- and capital-intensive industries, induced investment amounts to 31 resp. 16 percent of total investment, in the skilled-labour-intensive industries to only 2.[23] The price which was paid

here were on average 2,400 fewer jobs per year, against almost 29,000 more per year in the labour-intensive and almost 19,000 more in the capital-intensive-industries. Thus, it becomes clear that in the latter industry aggregates, labour shedding would have been even worse without the subsidies. As suspected, unskilled labour suffers more resp. benefits less from investment subsidization.

Coming to the total wage elasticities of the labour aggregates, they lie between -0.1 and -0.5, differing according to industries and meaning that a 1-percent-rise in wages ceteris paribus leads to a 0.1- to 0.5-percent reduction in additional jobs. The elasticity of unskilled labour is higher, a result being perfectly in line with the findings of Fitzroy and Funke (1998). The total wage elasticities of labour demand are weakest in the labour-intensive-industry aggregate, presumably because wages are not so crucial for competitiveness in rather locally oriented branches.

The reduction in employment resulting from the actual wage increases for skilled and unskilled labour can be seen in Table 12. Note that the reduction for both labour aggregates does not only consider the own-price effect, but includes the cross-price effect, i.e. the effect of an increase in wages of the other labour aggregate. These cross-price effects are partly negative like in the skilled-labour-

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[23] Casting a quick glance on wage development and investment, rising wages contribute to increases in most industries and thus reinforce the positive subsidy effects. Again, the skilled-labour-intensive industries represent an exception; here, the negative output effect of wage increases prevails.

intensive industries where obviously the output effect dominates, but mostly positive with the substitution effect prevailing so that a rise in the wages of one labour aggregate leads to higher employment in the other and thus reduces the own-price effect. The wage increases considered differentiate between wage increases for unskilled and skilled labour when regarding the substitution effect, but refer to labour as a whole when regarding the output effect.

It becomes quite clear that, neglecting capital costs, a lot more jobs could have been saved and created in eastern German manufacturing without augmenting wages as much as was done during transition. Keeping wages constant, there would be roughly 285,000 jobs more for unskilled and 265,000 more for skilled workers. Especially employment in the skilled-labour-intensive industries where wages represent an important share in all costs and besides a decisive aspect of competitiveness would have benefited from wage restraints and would not have lost so much of its share in total manufacturing employment (see section II). Here, the story of the employment disaster during transition seems to be essentially one of too rapid wage increases, which caused many firms to close down because of cost squeezes. Considering this, it almost seems like sarcasm that of all industries, wages increases were greatest in the skilled-labour-intensive ones.

Obviously, the results presented above do not give a complete picture. One piece of evidence is the very low percentage of unskilled jobs lost in the labour-intensive industries which does not quite fit with the data. Partly, this might be explained by the negative trend — which, however, is also present in other industry aggregates; partly, the variations remain unexplained by the model, which is reflected by the R^2 for unskilled labour in the labour-intensive industries being particularly low. Particularly in these and in the capital-intensive branches, aspects apart from wages must have played an important role in the massive dismissals and the small number of new jobs being created. It is likely that many jobs were rationalised away disregarding wages because they or their qualifications were simply not needed any more in a market economic production environment. Naturally, the bulk of this rationalisation took place in the beginning of transition when the lion’s share of jobs got lost. It may well be that this kind of rationalisation potential was largest in the capital- and labour-intensive industries — for the former, it is even quite intuitive considering the outdated equipment with a comparably high labour intensity which does not at all fit with branches that are supposed to use capital equipment intensively. A very illustrative example is the mineral oil industry where only a sixth of all skilled (!) labour jobs still existed in 1998 while capital intensity was massively augmented. Beside these possible explanations for the labour shedding remaining unexplained it should never be forgotten that the figures given are figures averaged over industries so that for some industries the fit might be better, for others worse.

Table 12 – Wage Increases and Consequent Job Reduction in Eastern Germany According to Labour and Industry Aggregates 1991-1998

	Capital-intensive industries	Skilled-labour-intensive industries	Labour-intensive industries
Average wage increase unskilled labour (percent)[a]	74	111	76
Average wage increase skilled labour (percent)[a]	103	148	99
Average wage increase, labour as a whole (percent)[b]	93	132	90
Reduction of unskilled labour due to wage increases:			
Percent	13	60	0.4
1,000 persons	34.5	218.0	4.8
Reduction of skilled labour due to wage increases:			
Percent	10	51	13
1,000 persons	35.8	174.6	18.3

[a]Sum of wage increases in each industry of the relevant industry aggregate, weighted with the cost share of labour of that industry in all industries of the same industry aggregate in 1991. – [b]Sum of wage increases of unskilled and skilled labour, weighted with the relative cost shares of both labour types in 1991.

Source: Own calculations.

Discussing the estimated effects on employment, a few more things have to be considered: First, it should be noted that employees of the salary category I, namely those belonging to the top management, are not included in the labour variables because of a lack of data. It can be expected that this group of employees is much less substitutable as to capital than those employees classified as skilled labour in this study — according to what we know in general about substitutability and complementarities among production factors, they should even be strongly complementary. Because business and managerial skills were highly neglected in the former GDR, the people being apt for top management have been and might still be scarce in eastern Germany.

Second, it might well be that the rumours of a rising lack of specialists in eastern Germany are true as some firms in some branches are indeed desperately looking for very special qualifications and cannot find the right person for a certain job on the eastern German labour market. These cases , however, cannot be generalised. A structural analysis of the lack of specialists yields that it is overall less urgent than in western Germany and that a rising lack can be interpreted as quite a normal development on the way towards market economic structures and processes. Branches most concerned are certain basic goods producers like chemicals and metal production and investment goods producers like machinery, motor cars and other vehicles, but also the construction and the services sector.[24] Because all these are fields where workers with specific qualifications are usually needed, this does not surprise. What must be conceded in the end is that these specific cases will spread in the near future and presumably become an important problem as more and more workers with top qualifications who are usually more mobile than their less qualified colleagues might leave eastern Germany, heading westwards where pay is much better.[25] Pay incentives and a more differentiated system of wages and salaries might be a reasonable solution.

c. *Effects of Investment Subsidization on Productivity and Growth*

An answer to the question whether investment subsidies have been able to tackle their third target beside enhancing structural change and competitiveness and fostering employment, namely contributing to growth and convergence, is given

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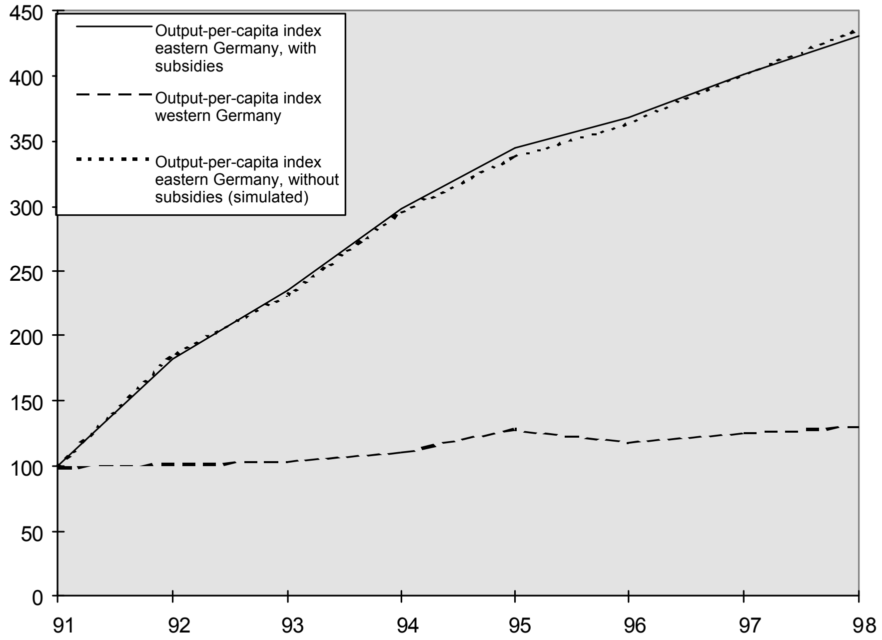
[24] For a more detailed analysis and data see DIW, IfW and IWH 1999.

[25] According to the statistics, 40,000 highly qualified specialists have left eastern Germany in 1999.

in Figures 2 to 4. They show the development of labour productivity — here simply measured as output per capita (employee) — in the different industry aggregates in eastern and western Germany from 1991 to 1998. The figures shown are those for eastern Germany as taken from the statistics (with subsidies) and those with additional productivity induced by subsidization each year subtracted (without subsidies). Subsidy-induced productivity is calculated from the estimated productivity effects of capital cost changes in tables 7 to 9 and the percentage of capital cost reduction due to subsidization each year. As a comparison, western German figures are also presented. The figures are expressed as an index with 1991=100 because it illustrates convergence or divergence more clearly (see e.g. Deitmer 1993).

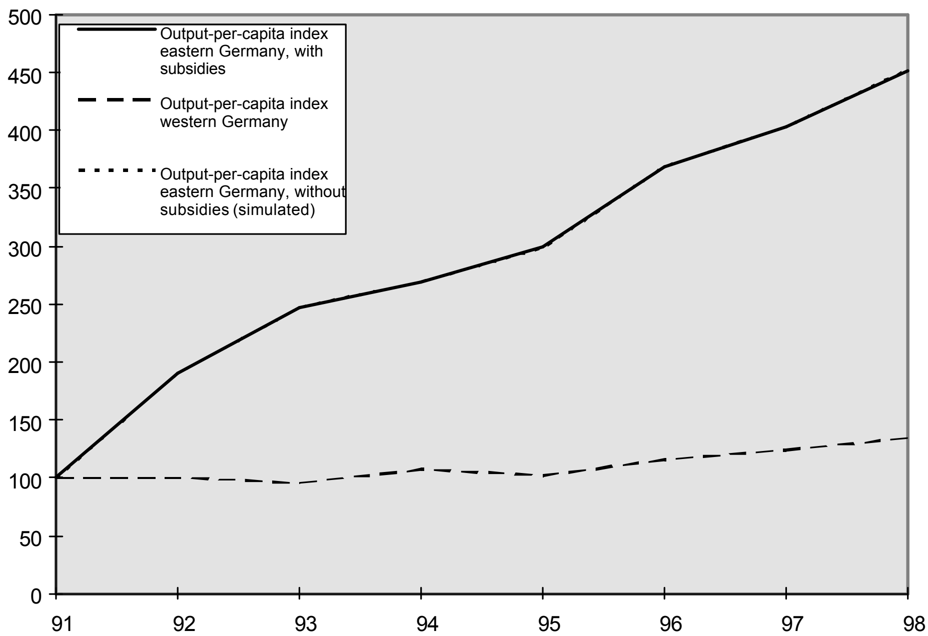
It is obvious that productivity levels in eastern German manufacturing have been catching up to western German levels from 1991 onwards, no matter if one looks at the figures with or without subsidization. Subsidization as granted in this period has not contributed to large extents to productivity growth at all, as can be seen from the straight line not lying far away from the dotted one. Broadly speaking, subsidization had a tiny positive impact on productivity convergence, i.e. on productivity growth being faster than in western German manufacturing, in periods where it was relatively high (first years of transition and recently) and a tiny negative impact in periods where it was relatively low (1993-1997). This means that in order to really push convergence one would have to grant enormous amounts of investment subsidies — an option which is not really available. All in all, the effect of investment subsidization on productivity growth and convergence can thus be considered negligible; moreover, conclusions as to productivity growth and convergence in the entire economy cannot be easily drawn because the figures presented here only concern the industrial sector.

Figure 2 – Output per Capita in the Capital-Intensive Industries 1991-1998 (1991=100)



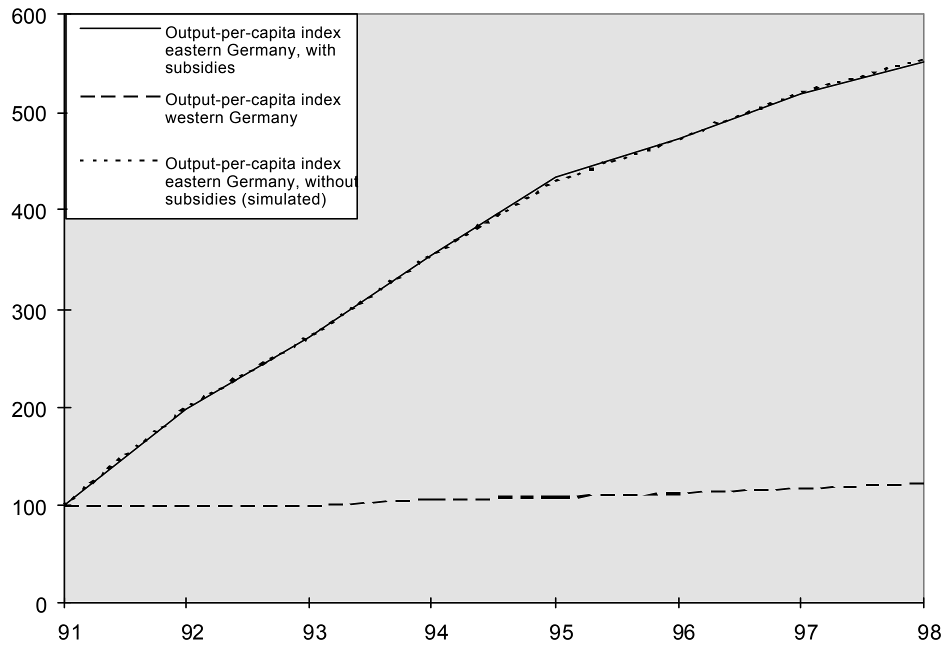
Source: Görzig and Noack (1999); own calculations.

Figure 3 – Output per Capita in the Skilled-Labour-Intensive Industries 1991-1998 (1991=100)



Source: Görzig and Noack (1999); own calculations.

Figure 4 – Output per Capita in the Labour-Intensive Industries 1991-1998 (1991=100)



Source: Görzig and Noack (1999); own calculations.

Evidently, the effects described above cannot be the whole story. Labour productivity depends on too many factors to be explained by simple algebra on labour reduction and output increases due to factor price changes. Among these are e.g. the state of the capital stock, management qualities, organizational structures, access to supply and sales networks and the market position. Some of these aspects might be strongly affected by investment and thus by subsidization so that its impact is much more complicated than the very basic calculations presented above. Unfortunately, many of the possible factors which are responsible for productivity development in eastern Germany are extremely difficult to observe, let alone to quantify.

V. Summary and Policy Implications

As usual in economic analysis, the answer as to the compatibility of subsidization with its objectives is mixed. What has to be stated first is certainly that the main policy guidelines of achieving equal living standards in east and west and a self-sustaining upswing in eastern Germany are not yet fulfilled, although the industrial sector seems to be on a good way towards sustainable growth; it has even taken over the role as the "locomotive" in the eastern German economy after the construction sector fell into deep recession in 1995. In order to conclusively assess inhowfar subsidization contributes to fostering eastern German adjustment and inhowfar it is in line with policy guidelines, one has to take a look at its targets again:

- Concerning structural change and competitiveness, the results of this study do not suggest that investment subsidies as granted to eastern German firms are the king's way to establish economic structures which are in line with the potential comparative advantages of a high-wage/high-skill economy as eastern Germany has become. The subsidies rather supported locally oriented branches, which faced favourable conditions during transition anyway.

- Concerning employment, the assessment of the subsidy effects is more positive than expected, especially concerning skilled labour. Due to production-enhancing effects of the subsidies, there would have been all in all more jobs destroyed if no subsidization had been granted. However, the jobs won are to be found exclusively in the capital- and particularly labour-intensive branches, i.e. those branches which are on the whole not really the basis for a competitive, export-oriented high-skill economy. If these jobs are competitive in the long run still has to be proved. Talking about positive employment effects of subsidization, it should not be forgotten that the subsidies had to struggle against the negative effects of the enormous wage increases.

- Concerning productivity and growth, the findings of the model are not able to tell a complete story but only one of the consequences of substitution and output effects on production and the workforce. However, in order to explain the eastern German "productivity riddle", i.e. that productivity in many branches keeps lagging behind the western German level while capital intensity has in some cases reached parity or even more, there are a lot of other factors to consider. Deficiencies in management qualities, organizational structures, access to supply and sales networks and the market position might e.g. cause several underutilised capacities.

To put it in a nutshell: investment subsidies have partly missed the objectives of economic policy in eastern Germany and have had some serious drawbacks, but they have not completely failed. It remains to be asked what the future picture will look like. Structural change has proceeded at a high speed in the past years and is still far from coming to an end. What the analysis here captures is the early period of transition with major structural adjustment as well as the later period of transition where the pace slowed down quite a bit. It may well be that the elasticities estimated are more or less influenced by this structural adjustment and might look a little different if a period from, say, 1995 to 2002 could be used as a basis for estimation.

What follows for future government policy now? It seems that, even if investment subsidies have partly met the objective of inducing investment and creating employment, this effect might lose importance soon because investment induced will probably be concentrated more and more on replacement instead of establishment of capacities so that the strong positive output effect in many industries is likely to shrink. The subsidies certainly had their peak season in the beginning of transition when they had to compensate potential investors for the serious locational disadvantages they faced in eastern Germany. Now, many established firms do not need them any more and those needing them might not be viable at all. A "subsidy mentality" is likely to develop. If a specific subsidy strategy for eastern Germany is nonetheless to be pursued, then it makes sense to think about linking subsidies to the creation of skilled jobs as e.g. suggested in Lammers and Thoroe (1982). However, such a strategy poses some new, especially practical problems which shall not be discussed in detail here.[26]

Instead of subsidies, there are two other areas which economic policy should focus in order to foster competitiveness, especially of firms in international competition:

The first is infrastructure where the DIW (2000) in a recent study found a gap of 30 percent as to the western level, concerning streets and educational infrastructure even of 50 percent. Here, a lot of investment is still needed. The second is wage and labour market policy. This study again proves that rapid wage adjustment is definitely a dangerous strategy for the competitiveness of the eastern German economy. If wage moderation was pursued in a stricter way, the unemployment problem could be tackled even without subsidization. However, next to wage moderation, it is necessary to allow for more differentiation in the wage

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[26] For discussion of alternative subsidy instruments see e.g. Adlung and Thoroe (1980) and Lichtblau (1995).

system in order to account for the stronger substitution of unskilled labour and for a potentially growing lack of highly qualified specialists who need incentives to stay in the east.

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Appendix A:

First Order Conditions of Nested CES Production Function

First stage:

$$\frac{K}{Q_{sub}} = d_2^{\,s_{sub}} \left(\frac{p_{Q_{sub}}}{c} \right)^{s_{sub}} \tag{A1}$$

$$\frac{L}{Q_{sub}} = \left(1 - d_2\right)^{s_{sub}} \left(\frac{p_{Q_{sub}}}{wl} \right)^{s_{sub}} \tag{A2}$$

with $s_{sub} = 1 / \left(1 + r_{sub}\right)$. (A3)

$$\overline{Q}_{sub} = \left[d_2 K^{-r_{sub}} + \left(1 - d_2\right) L^{-r_{sub}} \right]^{-\frac{1}{r_{sub}}} \tag{A4}$$

Second stage:

$$\frac{SL}{Q^d} = n^s d_1^{\,s} \left(\frac{p_Q}{wsl} \right)^s \left(A(t)\right)^{-(1-s)/n} \tag{A5}$$

$$\frac{Q_{sub}}{Q^d} = n^s \left(1 - d_1\right)^s \left(\frac{p_Q}{p_{Q_{sub}}} \right)^s \left(A(t)\right)^{-(1-s)/n} \tag{A6}$$

$$\overline{Q} = A(t)\left[d_1 SL^{-r} + \left(1 - d_1\right) Q_{sub}^{\;-r} \right]^{-\frac{n}{r}} \tag{A7}$$

with $s = 1 / \left(1 + r\right)$ and $d = \dfrac{1 - s + ns}{n}$ (A8)

Appendix B:

Conditions and Subsidy Equivalents of Selected Investment Subsidies

Investment bonus

Important features:

- only available for equipment, not for buildings;
- not subject to taxation;
- subsidy rates vary according to year, firm size and ownership status;
- the rates are to full extent subsidy equivalent.

Thus, the subsidy equivalent of the bonus, $g1$, is calculated as follows:

$$g1_t = s_{equip,t} * \left[\left(1 - s_{SME,t} - s_{east,t}\right) S_{g1,large,t} + s_{SME,t} S_{g1,SME,t} + s_{east,t} S_{g1,east,t}\right] \quad \text{(A9)}$$

with s_{equip} being the share of equipment investment in total investment, S_{g1} the subsidy rate differentiated according to firm category (large firms, SMEs being regarded as all enterprises with fewer than 200 employees, and firms owned by eastern Germans) and year, s_{SME} the investment share of SMEs and s_{east} that of enterprises in eastern German ownership, both the latter are only applying to those years where a differentiation of subsidy rates was in force; in all other years, they are zero.

Investment grant

Important features:

- available for equipment investment as well as for buildings;
- rates vary according to year and firm size; from 1991 until 1994 instead according to type of investment;
- investment grant rates are — like the bonus — to full extent subsidy equivalent;
- the grant is subject to taxation, which is integrated into the model indirectly via a deduction of the investment grant rate from allowable depreciation so that taxable profits are increased (Asmacher, Schalk and Thoss 1987).
- cumulation among subsidy instruments is possible. As an upper limit, the maximum subsidy equivalent of all cumulated subsidies of 35 percent as fixed by EU regulations is valid. Here, it is simply assumed that this limit is not exceeded; Concerning the investment grant, cumulation with reduced-interest loans as granted by the KfW and DtA is possible for SMEs up to 85 percent of the investment sum. It is supposed, that those SMEs which did actually cumulate[27] first fully claimed the bonus and the grant and filled up the rest with the loans. Furthermore, cumulation of grant and loans is regarded to be only relevant for analysis in the years 1991-1994; after that,

[27] It is assumed that all those SMEs which did receive the grant belong to this category because it is expected that the KfW- and DtA-loans are claimed by SMEs anyway since they are especially designed for these firms.

grant conditions changed fundamentally and it is assumed here that the upper limit of subsidy equivalent of 35 percent is then reached without cumulation.

Summing up, the rate of the investment grant for the period 1991-1994 is calculated as follows:

$$g2_t = (1 - s_{SME,t})(0.23 s_{estab,t} + 0.20 s_{expan,t} + 0.15 s_{modern,t}) + s_{SME,t} s_{g2,t} * (0.23 s_{estab,t} + 0.20 s_{expan,t} + 0.15 s_{modern,t}) \quad \text{(A10)}$$

with 0.23, 0.20 and 0.15 being the subsidy rate differentiated according to investment type (establishment, expansion or rationalization and modernization, weighted with the corresponding shares of investment of each type in each industry, s_{estab}, $s_{\exp an}$ and $s_{\mathrm{mod}\,ern}$; s_{SME} being the share of investment in SMEs, which are here (unlike concerning the bonus) defined as enterprises with fewer than 500 employees, and s_{g2} that of SMEs which were actually grant-subsidized[28], both the latter taken together representing the share of firms which are assumed to cumulate.

For the period 1995-1998, the rate looks like

$$g2_t = (1 - s_{SME,t}) * S_{g2,large,t} + s_{SME,t} s_{g2,t} * S_{g2,SME,t} \quad \text{(A11)}$$

with the subsidy rate S_{g2} only differentiated according to firm size.

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[28] As some of the SMEs only claimed the loans until their subsidy limit was reached because the loans are a specific SME subsidy instrument and thus did not cumulate, this share is introduced here.

Depreciation allowance

The discounted tax advantage resulting from the depreciation allowance is:

$$u*DA = e\sum_{t=1}^{10}\frac{u_t\left(d1_t - d0\right)}{1+i_t\left(1-u_t\right)} + b\sum_{t=1}^{25}\frac{u_t\left(d1_t - d0\right)}{1+i_t\left(1-u_t\right)} \qquad \text{(A12)}$$

with DA representing the depreciation allowance, e the share of equipment investment, b the share of buildings, $d0$ the normal depreciation allowance without considering subsidization and $d1$ the extra depreciation allowance due to subsidization.

Subsidized loans

The discounted interest rate differential between the rate of the loan and market interest rates is for each loan program calculated as follows:

$$S_{loan,t} = \sum_{t=1}^{n} K_0\left(1-\frac{t-1}{n}\right)\Delta i_0\left(1-j\right)^{-t} \qquad \text{(A13)}$$

where n is the life of the loan, K_0 the amount of the loan, Δi the interest rate differential compared to market rates and j the discount rate (here: 10 percent).

As conditions vary greatly over programs (see table), this subsidy equivalent has to be calculated for each program and then weighted by the share of the program in the amount of total loans granted by the KfW and DtA. It has to be noted that only the interest rate differential is considered as subsidy in this analysis; other favourable condition like e.g. years free of discharge are neglected for reasons of simplification.

Table – Conditions of Selected Subsidized Loans

	1991	1992	1993	1994	1995	1996	1997	1998
KfW Investitionskredit-programm (investment credit program)	i=7.5 n=10 f=2	i=7.5 n=10 f=2	-	-	-	-	-	-
KfW Mittelstandspro-gramm (program for SMEs)	i=8 n=10 f=2	i=7.75 n=10 f=2	i=6.25 n=10 f=2	i=6 n=10 f=2	i=5.75 n=10 f=2	i=5.5 n=10 f=2	i=4.5 n=10 f=2	i=4.25 n=10 f=2
DtA Existenzgründungs-programm (program for newly founded firms)	i=8 n=10 f=2	i=8 n=10 f=2	i=6.25 n=10 f=2	i=6.15 n=10 f=2	i=5.75 n=10 f=2	i=5.25 n=10 f=2	i=4.5 n=10 f=2	i=4.25 n=10/20 f=2/3[a]
ERP-programs (program for newly founded firms and reconstruction pro-gram)	i=7.5 n=15 f=5	i=7.5 n=15 f=5	i=6.25 n=15 f=5	i=6 n=15 f=5	i=6 n=15 f=5	i=5.5 n=15 f=5	i=4.75 n=15 f=5	i=4.5 n=15 f=5

i: interest rate in percent; n: life of loan; f: maximum years free of discharge

[a]10 years for equipment investment with 2 years free of discharge, 20 years for buildings with 3 years free of discharge.

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

1991-1996:		1997:		1998:	
i=0	first to third year	i=0	first to second year	i=0	first to second year
i=2	fourth year	i=3	third year	i=3	third year
i=3	fifth year	i=4	fourth year	i=4	fourth year
i=5	sixth year	i=5	fifth year	i=5	fifth year
		i=7	sixth to tenth year	i=6.75	sixth to tenth year

with n=20 and f=10 (in all other years: no reduced interest rate)

Source: BMWi.

In order to obtain the final subsidy rate of the loans altogether, $loan$, the subsidy equivalent as calculated above for each loan program i has to be multiplied by the maximum share in investment up to which firms are allowed to take up a certain loan, $s_{\max,i}$ (varies according to program), by the share of investment of SMEs for which these loans are designed, s_{SME} (here: share of investment by enterprises with fewer than 500 employees) and by the share of investment by SMEs which did not receive the grant, $\left(1-s_{g2}\right)$, the latter because it is assumed here that SMEs in the years 1995-1998 either receive the grant or the loans alone and in the years 1991-1994 either receive the grant alone or cumulate:

$$loan_t = s_{SME,t}\left(1 - s_{g2,t}\right)\sum_i s_{\max,i,t} S_{loan,i,t} \qquad \text{(A14)}$$

In order to account for cumulation possibilities in the years 1991-1994, the following term is added to the rate above:

$$loan_{cumulated,t} = s_{SME,t} s_{g2,t} * \left(0.85 - 0.23 - g1_t\right)\sum_i s_{\max,i,t} S_{loan,i,t} \qquad \text{(A15)}$$

It calculates the share of subsidization in investment which is still "free" to be taken up by the loans in cumulation, i.e. the highest possible subsidy share in investment (85 percent) minus the grant (here the maximum rate is chosen for simplification) and the bonus which all firms are assumed to have claimed.

Considering these instruments, the subsidy rate s applying in the user cost of capital results as $g1_t + g2_t + loan_t + \left(1 - g2_t\right)u * DA$.

Appendix C:

Panel Cointegration Statistics according to Pedroni (1997 and 1999)

1. Panel variance-ratio (v) statistic:

$$T^2 N^{3/2} Z_{\hat{v}_{NT}} \equiv T^2 N^{3/2} \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{u}_{i,t-1}^{2} \right)^{-1} \quad \text{(A15)}$$

2. Panel r-statistic:

$$T\sqrt{N} Z_{\hat{r}_{NT^{-1}}} \equiv T^2 \sqrt{N} \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{u}_{i,t-1}^{2} \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left(\hat{u}_{i,t-1} \Delta \hat{u}_{it} - \hat{l}_i \right) \quad \text{(A16)}$$

3. Panel t-statistic:

$$Z_{t_{NT}} \equiv \left(\tilde{s}_{NT}^{2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{u}_{i,t-1}^{2} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left(\hat{u}_{i,t-1} \Delta \hat{u}_{it} - \hat{l}_i \right) \quad \text{(A17)}$$

4. Panel ADF statistic:

$$Z_{t_{NT}}^{*} \equiv \left(\tilde{s}_{NT}^{*2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{u}_{i,t-1}^{*2} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{u}_{i,t-1}^{*} \Delta \hat{u}_{it}^{*} \quad \text{(A18)}$$

5. Group r-statistic:

$$T\sqrt{N} \tilde{Z}_{\hat{r}_{NT^{-1}}} \equiv T^2 \sqrt{N} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \hat{u}_{i,t-1}^{2} \right)^{-1} \sum_{t=1}^{T} \left(\hat{u}_{i,t-1} \Delta \hat{u}_{it} - \hat{l}_i \right) \quad \text{(A19)}$$

6. Group t-statistic:

$$\sqrt{N}\tilde{Z}_{t_{NT}} \equiv \sqrt{N}\sum_{i=1}^{N}\left(\hat{s}_i^{\,2}\sum_{t=1}^{T}\hat{u}_{i,t-1}^{2}\right)^{-1/2}\sum_{t=1}^{T}\left(\hat{u}_{i,t-1}\Delta\hat{u}_{it} - \hat{l}_i\right) \qquad \text{(A20)}$$

7. Group ADF statistic:

$$\sqrt{N}\tilde{Z}_{t_{NT}}^{*} \equiv \sqrt{N}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\hat{s}_i^{*2}\hat{u}_{i,t-1}^{*2}\right)^{-1/2}\sum_{t=1}^{T}\hat{u}_{i,t-1}^{*}\Delta\hat{u}_{it}^{*} \qquad \text{(A21)}$$

where $\hat{l}_i = \frac{1}{T}\sum_{s=1}^{k_i}\left(1-\frac{s}{k_i+1}\right)\sum_{t=s+1}^{T}\hat{m}_{it}\hat{m}_{i,t-s}$; $\hat{s}_i^2 = \frac{1}{T}\sum_{t=1}^{T}\hat{m}_{it}^2$; $\hat{s}_i^{\,2} = \hat{s}_i^2 + 2\hat{l}_i$;

$\tilde{s}_{NT}^{\,2} = \frac{1}{N}\sum_{i=1}^{N}\hat{L}_{11i}^{-2}\hat{s}_i^{\,2}$; $\hat{s}_i^{*2} = \frac{1}{T}\sum_{t=1}^{T}\hat{m}_{it}^{*2}$; $\tilde{s}_{NT}^{*2} = \frac{1}{N}\sum_{i=1}^{N}\hat{s}_i^{*2}$;

$$\hat{L}_{11i}^{2} = \frac{1}{T}\sum_{t=1}^{T}\hat{h}_{it}^{2} + \frac{2}{T}\sum_{s=1}^{k_i}\left(1-\frac{s}{k_i+1}\right)\sum_{t=s+1}^{T}\hat{h}_{it}\hat{h}_{i,t-s}$$

and where the residuals $\hat{m}_{it}, \hat{m}_{it}^{*}$ and $\hat{h}_{it}$ are obtained from the regressions:

$$\hat{u}_{it} = r_i\hat{u}_{i,t-1} + \hat{m}_{it}, \quad \hat{u}_{it} = r_i\hat{u}_{i,t-1} + \sum_{k=1}^{K_i}\hat{g}_{ik}\Delta\hat{u}_{i,t-k} + \hat{m}_{it}^{*}, \quad \Delta y_{it} = \sum_{m=1}^{M}\hat{b}_{mi}\Delta X_{mit} + \hat{h}_{it}$$

Appendix D:

Tables

Table A1 – Factor Intensity of Manufacturing Industries

Industry (NACE classification)	Fixed capital intensity[a] (1000 DM)	Skilled-labour intensity[b] (1000 DM)	Classification[c]
Food, beverages	367.0	63.8	K
Tobacco[d]	549.2	302.7	K
Textiles	362.4	87.4	K
Clothing	181.3	45.8	L
Leather	288.2	90.1	K
Wood (excl. furniture)	230.0	93.6	L
Paper	382.4	136.0	K
Printing[e]	329.4	153.1	K
Mineral oil, cokery	1329.1	304.3	K
Chemicals	431.3	269.1	K
Plastics, rubber	228.1	115.7	L
Glass, pottery, stone and clay	344.4	132.3	K
Metal production	439.4	146.4	K
Constructional steel	136.6	148.8	L
Metal products	209.9	120.2	L
Machinery	173.4	198.9	SL
Office machinery	441.2	367.2	SL
Electrical engineering	191.5	212.9	SL
Media technology	292.7	266.6	SL
Measuring and control technology, optics	177.8	203.8	SL
Motor cars	278.9	207.5	SL
Other vehicles	223.4	248.4	SL
Furniture, toys	160.1	100.0	L
Note: Total manufacturing[e,f]	272.7	167.4	-

[a]Gross capital stock per employed person 1994, western Germany (in constant prices of 1991). – [b]Skilled labour per employee 1994, western Germany; calculated according to the following equation: $SL/E = (WS/E - w_L)/i_{SL}$ with SL: skilled labour, comprising workers in wage category 1 and employees in salary categories II and III (note that the skilled labour definition is a little bit broader than in the model estimations), E: employees 1994, WS: wages and salaries, w: wages and salaries of workers in low wage and salary categories (wage categories 2 and 3; salary category IV and V), i_{SL}: estimated interest rate on skilled labour (10 percent). – [c]SL: skilled-labour-intensive; K: fixed capital-intensive; L: labour-intensive. – [d]In the further analysis put into one aggregate with food and beverages. – [e]Excluding publishing. – [f]Excluding recycling.

Source: Statistisches Bundesamt (1994a, 1994b, 1996), own calculations.

Table A2 – User Cost of Capital in Eastern German Industries Including Investment Subsidies, 1991–1998 (DM per DM 100 of capital)

	1991	1992	1993	1994	1995	1996	1997	1998
	Capital-intensive industries							
Food, beverages, tobacco	6.09	5.36	4.76	4.59	4.59	5.12	5.35	5.52
Textiles	5.66	6.14	4.98	4.27	4.01	4.00	4.05	4.08
Leather	5.65	4.52	3.81	3.57	4.18	4.19	4.27	4.32
Paper	5.74	6.02	3.91	4.85	4.72	4.69	4.58	4.58
Printing[a]	7.41	5.92	4.76	4.52	4.43	4.46	4.57	4.66
Mineral oil. cokery	5.83	6.15	5.58	5.18	5.21	5.10	5.32	5.45
Chemicals	5.85	6.46	5.39	5.01	4.78	4.72	4.88	4.97
Glass. pottery. stone and clay	5.80	6.73	6.07	5.37	5.16	5.13	5.36	5.95
Metal production	6.16	6.80	5.70	5.26	4.63	4.61	4.77	4.88
	Skilled-labour-intensive industries							
Machinery	6.12	6.24	5.16	5.15	4.93	4.98	5.16	5.30
Office machinery	5.52	13.53	3.93	3.99	5.55	5.78	6.07	6.34
Electrical engineering	6.18	5.77	5.31	4.71	4.32	4.32	4.41	4.88
Media technology	6.18	5.77	5.31	4.71	4.32	4.32	4.41	4.88
Measuring and control technology. optics	5.19	4.75	3.60	3.43	4.34	4.40	4.52	4.61
Motor cars	5.82	5.92	4.90	4.63	4.21	4.23	4.31	4.35
Other vehicles	5.78	5.64	4.58	4.26	4.42	4.40	4.51	4.58
	Labour-intensive industries							
Clothing	6.15	4.93	4.81	4.14	4.97	5.07	5.26	5.43
Wood (excl. furniture)	5.59	5.60	4.42	4.34	4.14	4.14	4.61	5.00
Plastics. rubber	5.93	5.76	4.75	4.39	4.34	4.33	4.43	4.79
Constructional steel	6.14	5.67	4.79	4.69	4.37	4.40	4.52	4.60
Metal products	5.79	5.57	4.41	4.31	4.08	4.09	4.17	4.22
Furniture, toys	5.48	4.81	4.21	4.09	3.90	3.92	4.36	4.42

[a]Excluding publishing.

Source: Own calculations.

Table A3 – Reduction of User Cost of Capital due to Investment Subsidies 1991–1998 (Percent)[a]

	1991	1992	1993	1994	1995	1996	1997	1998
	Capital-intensive industries							
Food. beverages. tobacco	26	23	26	29	29	28	26	25
Textiles	27	25	28	29	26	24	23	22
Leather	29	24	25	24	26	24	23	22
Paper	29	25	46	32	29	27	25	19
Printing[b]	17	14	16	18	27	25	23	22
Mineral oil. cokery	23	25	30	30	29	28	26	25
Chemicals	26	24	27	29	29	27	26	25
Glass. pottery. stone and clay	31	25	30	33	29	27	26	18
Metal production	28	25	29	28	29	28	26	25
	Skilled-labour-intensive industries							
Machinery	25	24	26	28	28	27	25	24
Office machinery	27	26	25	25	29	27	25	24
Electrical engineering	26	23	26	28	28	26	25	24
Media technology	26	23	26	28	28	26	25	24
Measuring and control technology. optics	26	23	21	19	28	26	25	24
Motor cars	28	23	26	27	28	26	25	24
Other vehicles	25	22	25	24	28	26	25	24
	Labour-intensive industries							
Clothing	28	22	26	26	27	25	23	22
Wood (excl. furniture)	27	24	26	28	26	25	24	17
Plastics. rubber	28	25	27	29	27	25	24	17
Constructional steel	25	22	25	25	28	26	25	24
Metal products	27	24	26	27	28	26	25	24
Furniture, toys	32	24	25	29	26	24	23	22

[a]Calculated as the sum of the subsidy equivalents of investment bonus. investment grant. depreciation allowance (only for profit-making firms) and loans. – [b]Excluding publishing.

Source: Own calculations.

Table A4 – Estimation Results: Unskilled-Labour Demand (Dependent Variable: $\Delta \ln L$)[a]

Variable	Capital-intensive industries	Labour-intensive industries	Skilled-labour-intensive industries
Adjustment parameter			
$\ln L_{-1}$	-0.48 (-8.19)	-0.24 (-1.54)	-0.87 (-6.23)
Long-run parameters			
$\ln\left(wl / p_{Q_{sub}}\right)_{-1}$	-0.60 (-3.61)	-0.83 (-3.32)	-0.31 (-1.61)
$\ln\left(p_{Q_{sub}} / p_Q\right)_{-1}$	-0.30 (-1.73)	-0.67 (-3.17)	-0.03 (-0.30)
$\ln Q_{-1}$	0.43 (5.48)	0.76 (8.48)	0.29 (4.72)
$trend_{-1}$[b]	0.03 (1.16)	-0.07 (-2.38)	-0.06 (-3.70)
Short-run parameters			
$\Delta \ln L_{-1}$	-	-	-
$\Delta \ln L_{-2}$	-	-	-0.18 (-2.95)
$\Delta \ln\left(wl / p_{Q_{sub}}\right)$	-	-	-
$\Delta \ln\left(wl / p_{Q_{sub}}\right)_{-1}$	-	-	-
$\Delta \ln\left(wl / p_{Q_{sub}}\right)_{-2}$	-	-	-
$\Delta \ln\left(p_{Q_{sub}} / p_Q\right)$	0.38 (3.34)	0.49 (2.16)	-
$\Delta \ln\left(p_{Q_{sub}} / p_Q\right)_{-1}$	-	-	-
$\Delta \ln\left(p_{Q_{sub}} / p_Q\right)_{-2}$	-	-	-
$\Delta \ln Q$	-	-	-
$\Delta \ln Q_{-1}$	-	-	-
$\Delta \ln Q_{-2}$	-	-	-
$\bar{R}^2$ [c]	0.83	0.32	0.56
$\bar{R}^2$ corrected[c]			
RSS[c]	0.58	0.28	0.26
SEE[c]	0.11	0.12	0.11
BP (sing. eq.)[d]	0.31	0.17	0.28
BP (sim. eq.)[d]	0.04	0.16	0.50

[a]t-statistics in brackets. A dash in a cell means that either a lag was not selected to be significant by the STEPWISE procedure or it was not considered because of a lower chosen lag order. – [b]A linear time trend is used in the equation to represent technical efficiency. – [c] $\bar{R}^2$, RSS (residual sum of squares) and SEE (standard error of estimate) are obtained from the simultaneous equation estimation of the ECM excluding bias-corrections. – [d]Significance level of c^2-statistic.

Source: Own calculations.

Table A5 – Estimation Results: Skilled-Labour Demand (Dependent Variable: $\Delta \ln SL$)[a]

Variable	Capital-intensive industries	Labour-intensive industries	Skilled-labour-intensive industries
Adjustment parameter			
$\ln SL_{-1}$	-0.66 (-11.57)	-0.49 (-3.96)	-0.46 (-4.06)
Long-run parameters			
$\ln(wsl / p_Q)_{-1}$	-0.30 (-1.73)	-0.67 (-3.17)	-0.03 (-0.30)
$\ln Q_{-1}$	0.43 (5.48)	0.76 (8.48)	0.29 (4.72)
$trend_{-1}$[b]	-0.04 (-1.82)	-0.01 (-0.83)	-0.03 (-1.46)
Short-run parameters			
$\Delta \ln SL_{-1}$	-	-0.42 (4.35)	-
$\Delta \ln SL_{-2}$	-	-0.11 (-1.62)	-
$\Delta \ln(wsl / p_Q)$	-	-	-
$\Delta \ln(wsl / p_Q)_{-1}$	-	-	-
$\Delta \ln(wsl / p_Q)_{-2}$	-	-	-
$\Delta \ln Q$	-	-	-
$\Delta \ln Q_{-1}$	-	-	-
$\Delta \ln Q_{-2}$	-	-	-
$\overline{R}^2$ c	0.85	0.64	0.39
$\overline{R}^2$ corrected[c]			
RSS[c]	0.64	0.12	0.22
SEE[c]	0.11	0.08	0.10
BP (sing. eq.)[d]	0.08	0.10	0.08
BP (sim. eq.)[d]	0.08	0.10	0.23

[a]t-statistics in brackets. A dash in a cell means that either a lag was not selected to be significant by the STEPWISE procedure or it was not considered because of a lower chosen lag order. – [b]A linear time trend is used in the equation to represent technical efficiency. – [c] $\overline{R}^2$, RSS and SEE are obtained from the simultaneous equation estimation of the ECM excluding bias-corrections. – [d]Significance level of c^2-statistic.

Source: Own calculations.

Table A6 – Estimation Results: Output (Dependent Variable: $\Delta \ln Q$)[a]

Variable	Capital-intensive industries	Labour-intensive industries	Skilled-labour-intensive industries
Adjustment parameter			
$\ln Q_{-1}$	-0.33 (-5.16)	-0.24 (-3.17)	-0.36 (-1.94)
Long-run parameters			
$\ln(w / trend)_{-1}$	0.10 (0.22)	1.06 (0.94)	-1.36 (-2.31)
$\ln(c / trend)_{-1}$	- 0.98(-2.86)	-1.35 (-1.90)	0.48 (1.47)
$\ln(p_T / p_{NT})_{-1}$[b]	0.59 (0.89)	1.90 (0.69)	-8.40 (-2.46)
$\ln construct_{-1}$[c]	-0.38 (-0.85)	-0.18 (-0.23)	-[d]
Short-run parameters			
$\Delta \ln Q_{-1}$	0.24 (2.29)	-	-
$\Delta \ln Q_{-2}$	-	-	-
$\Delta \ln w$	-	-	-
$\Delta \ln w_{-1}$	-	-	-
$\Delta \ln w_{-2}$	-	-	-
$\Delta \ln c$	-	-	-
$\Delta \ln c_{-1}$	0.23 (1.75)	-	-
$\Delta \ln c_{-2}$	-	-	-
$\Delta \ln(p_T / p_{NT})$	-	-	-
$\Delta \ln(p_T / p_{NT})_{-1}$	-	-	23.58 (4.35)
$\Delta \ln(p_T / p_{NT})_{-2}$	-	-	-
$\Delta \ln construct$	0.85 (3.61)	0.57 (2.11)	-
$\Delta \ln construct_{-1}$	-	-	-
$\Delta \ln construct_{-2}$	-	-	-
$\bar{R}^2$[e]	0.66	0.69	0.50
$\bar{R}^2$ corrected[e]			
RSS[e]	0.24	0.25	0.68
SEE[e]	0.08	0.09	0.17
BP[f]	0.01	0.18	0.29

[a]t-statistics in brackets. A dash in a cell means that either a lag was not selected to be significant by the STEPWISE procedure or it was not considered because of a lower chosen lag order. – [b]Ratio of price index of tradeable and non-tradeable goods. – [c]Index of production in the construction sector, 1995=100. – [d]Left out of equation for stability reasons, see text for details. – [e]$\bar{R}^2$, RSS and SEE are obtained from the ECM estimation of the output equation excluding bias-corrections. – [f]Significance level of c^2-statistic.

Source: Own calculations.

Table A7 – Corrections for the Nickell-Bias: Unskilled-Labour Demand[a]

Variable	Capital-intensive industries	Labour-intensive industries	Skilled-labour-intensive industries
Adjustment parameter			
$\ln L_{-1}$	+0.180	+0.113	+0.192
Long-run parameters			
$\ln\left(wl / p_{Q_{sub}}\right)_{-1}$	+0.014	-0.175	-0.027
$\ln\left(p_{Q_{sub}} / p_Q\right)_{-1}$	+0.047	-0.114	-0.024
$\ln Q_{-1}$	-0.126	-0.002	+0.037
$trend_{-1}$[b]	+0.058	+0.031	+0.004
Short-run parameters			
$\Delta \ln L_{-1}$	-	-	-
$\Delta \ln L_{-2}$	-	-	+0.018
$\Delta \ln\left(wl / p_{Q_{sub}}\right)$	-	-	-
$\Delta \ln\left(wl / p_{Q_{sub}}\right)_{-1}$	-	-	-
$\Delta \ln\left(wl / p_{Q_{sub}}\right)_{-2}$	-	-	-
$\Delta \ln\left(p_{Q_{sub}} / p_Q\right)$	0.000	-0.063	-
$\Delta \ln\left(p_{Q_{sub}} / p_Q\right)_{-1}$	-	-	-
$\Delta \ln\left(p_{Q_{sub}} / p_Q\right)_{-2}$	-	-	-
$\Delta \ln Q$	-	-	-
$\Delta \ln Q_{-1}$	-	-	-
$\Delta \ln Q_{-2}$	-	-	-

[a]For reasons of simplification, corrections for individual-specific dummy variables are not reported here.

Source: Own calculations.

Table A8 – Corrections for the Nickell-Bias: Skilled-Labour Demand[a]

Variable	Capital-intensive industries	Labour-intensive industries	Skilled-labour-intensive industries
Adjustment parameter			
$\ln SL_{-1}$	+0.011	+0.207	+0.020
Long-run parameters			
$\ln(wsl / p_Q)_{-1}$	+0.005	-0.055	-0.042
$\ln Q_{-1}$	-0.010	-0.005	+0.038
$trend_{-1}$[b]	+0.003	+0.015	+0.019
Short-run parameters			
$\Delta \ln SL_{-1}$	-	-0.065	-
$\Delta \ln SL_{-2}$	-	-0.007	-
$\Delta \ln(wsl / p_Q)$	-	-	-
$\Delta \ln(wsl / p_Q)_{-1}$	-	-	-
$\Delta \ln(wsl / p_Q)_{-2}$	-	-	-
$\Delta \ln Q$	-	-	-
$\Delta \ln Q_{-1}$	-	-	-
$\Delta \ln Q_{-2}$	-	-	-

[a]For reasons of simplification, corrections for individual-specific dummy variables are not reported here.

Source: Own calculations.

Table A9 – Corrections for the Nickell-Bias: Output[a]

Variable	Capital-intensive industries	Labour-intensive industries	Skilled-labour-intensive industries
Adjustment parameter			
$\ln Q_{-1}$	+0.057	+0.063	+0.35
Long-run parameters			
$\ln(w / trend)_{-1}$	+0.074	-0.101	-0.333
$\ln(c / trend)_{-1}$	-0.157	+0.055	-0.192
$\ln(p_T / p_{NT})_{-1}$[b]	-0.009	+0.257	+1.068
$\ln construct_{-1}$	-0.011	+0.189	-[b]
Short-run parameters			
$\Delta \ln Q_{-1}$	+0.135	-	-
$\Delta \ln Q_{-2}$	-	-	-
$\Delta \ln w$	-	-	-
$\Delta \ln w_{-1}$	-	-	-
$\Delta \ln w_{-2}$	-	-	-
$\Delta \ln c$	-	-	-
$\Delta \ln c_{-1}$	+0.144	-	-
$\Delta \ln c_{-2}$	-	-	-
$\Delta \ln(p_T / p_{NT})$	-	-	-
$\Delta \ln(p_T / p_{NT})_{-1}$	-	-	-1.663
$\Delta \ln(p_T / p_{NT})_{-2}$	-	-	-
$\Delta \ln construct$	+0.49	+0.044	-
$\Delta \ln construct_{-1}$	-	-	-
$\Delta \ln construct_{-2}$	-	-	-

[a]For reasons of simplification, corrections for individual-specific dummy variables are not reported here. – [b]Not included in the equation.

Source: Own calculations.

Table A10 – AES and "Own" Elasticities of Substitution in Eastern German Industries

	Capital-intensive industries	Skilled-labour-intensive industries	Labour-intensive industries
$s_{SLQ_{sub}} = s_{SLL} = s_{SLI}$	0.61	0.00	0.77
s_{IL}	0.83	0.71	0.84

Source: Own calculations.