Regional investment incentives in Germany: Impacts on factor demand and growth

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Abstract. The aim of this paper is to analyse the effects of regional investment incentives — a main component of regional policy in West Germany — on regional factor demand (investment and labor), growth and convergence of per capita income for the period 1978 to 1989. Demand for investment and labor arise from a model of cost minimization at given output with a putty-clay production function. The production function allows for regional technical efficiency. To model the output effect on factor demand an auxiliary output function is specified. In estimating the functions attention is given to the short-run dynamics and the long-run behaviour of factor demand by error-correction models. The empirical long-run relationships are then used to simulate the effects of regional investment incentives. In contrast to most studies for other countries the empirical results provide evidence that regional policy in Germany induces not only additional investment but also creates positive employment effects. However, the effects of regional investment incentives on growth and convergence of labor productivity are negligible.

1. Introduction

Regional economic policy in Germany has been a joint task of the federal government and the states (Länder) since 1969. In the main, regional policy has relied on different kinds of investment incentives in regions with relatively high unemployment rates and low per capita income in order to induce additional investment to create jobs and to increase growth in low income regions to equalize interregional per capita income.

From the beginning and increasingly since the 1980s this kind of regional

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economic policy has been criticized for various reasons. First, regional capital subsidies do not succeed in stimulating additional investment. Firms invest no more than they would without capital grants. Second, even if additional investments are induced, the direct impact of investment subsidies is more likely to reduce the demand for labor than to increase it, since it raises the cost of labor relative to capital which results in a substitution of capital for labor. Third, the interregional income disparities between the ‘rich’ and the ‘poor’ assisted regions have not been reduced significantly.

While it is by now generally accepted that regional capital incentives induce additional investment (Daly et al. 1993, Faini and Schiantarelli 1985, Franz and Schalk 1982, 1989, Harris 1991a, and Luger 1984), it is still doubtful whether the employment target can be reached by this policy strategy. Most of the empirical findings indicate a nearly negligible or even negative employment effect (e.g. Daly et al. 1993, Faini and Schiantarelli 1985, Folmer and Nijkamp 1987). However, in those studies the substitution effect evoked by the reduction of the user cost of capital relative to the labor cost is overemphasized while the output effect is mostly not taken into account or modelled adequately. An output effect may arise for two reasons: First, reduced total costs induce firms located in the assisted areas to expand production and purchase more of all inputs. Second, interregional differences in the user cost of capital stimulates investors in the non-assisted areas to shift production into the assisted areas, again leading to an increase in capital and labor demand. Therefore, whether regional investment incentives increase or decrease labor demand depends on the size of the substitution and output effect. Employment will rise only if the output effect outweighs the substitution effect.

The third critique rests on the observation that labor productivity differentials between assisted and non-assisted areas have not diminished but have even slightly increased (Koller 1990 and Deutscher Bundestag 1992, p. 14). However, from this alone it cannot be concluded that regional policy has failed with respect to the regional equity target because income divergences could be still larger without regional policy. According to the neoclassical growth theory interregional convergence of labor productivity requires higher growth of the capital-labor ratio in the poorer regions than in the rich ones. Labor productivity, though, is also affected by the level of technology or technical efficiency, which can be modelled as a Hicks-neutral shifter term in an aggregate production function (Beeson and Husted 1991, Schalk, Untiedt and Luschow 1995) and which reflects the efficiency of all the employed production factors. Thus the question arises as to whether regional policy has failed to increase capital intensity and technical efficiency in low productivity regions. For this to be assessed an impact analysis of regional investment incentives on labor productivity is required.

Despite the criticism, the whole system of regional capital subsidies in West Germany was carried over to East Germany following German unification. Even the automatic capital investment bonus which is suspected of high bandwagon effects and had been abolished in West Germany in 1990

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1 See Scharf (1993) for further critique of the German regional policy. With similar arguments the regional capital subsidies in other countries have been criticised, e.g. Daly et al. (1993) for Canada, Folmer and Nijkamp (1987) for the Netherlands, Harris (1991a) for Northern Ireland and Luger (1984) for the U.S.
Regional investment incentives in Germany. Thus, regional economic policy adheres to instruments with unclear or contentious effects. Why should a policy, which has allegedly failed in West Germany, be able to support efficiently the restructuring and catching-up process in East Germany?

The organization of this paper is as follows: Sect. 2 reviews the theoretical model for evaluating regional policy in Germany, consisting of relationships for factor demand and output growth. In Sect. 3 a description of the econometric approach employed is given and the empirical results are presented. These are used to simulate the impacts of regional policy on investment, employment, growth and convergence in the assisted areas of West Germany. Finally, Sect. 4 summarizes our findings and conclusions.

2. Theoretical considerations

The model on which our impact analysis of the German regional economic policy is founded consists of three equations: two factor demand functions for investment and labor, and an output function. The specification for the econometric model equations draws on different theoretical and empirical research efforts which are well known in the economics literature. Thus we can confine ourselves to a description of the main features of the approach adopted for analysing the effects of investment subsidies in a regional context.

2.1. Factor demand

The specification of the factor demand equations is based on standard theory of the firm which is able to account for the simultaneity and mutual interdependence of the decisions of the firms concerning investment, employment and output. There are, at least, two key assumptions. The first concerns the form of the underlying production function and the second the economic behaviour of the firm (profit maximization or cost minimization). For the derivation of the factor demand functions we have adopted a putty-clay production function and suppose that the firms minimize their production costs at a given output.

It is assumed that the firm’s choice of production techniques can be represented by a production function in which capital is viewed as putty-clay, i.e. exante substitutability between capital and labor is assumed but fixed expost proportions after capital installation. If \( I_t \) represents machines (gross investment) in period \( t \) that are combined with labor employed on these machines \( AE_t \) to produce the desired increase in gross output, \( \Delta Y_t \), the exante production function can be written in its general form as (the superscript \( r \) is for ‘regions’):

\[
\Delta Y_t^r = f(AE_t^r, I_t^r, TE^r),
\]

(1)

where, in addition, \( TE \) is a regional-specific technology parameter which reflects the technical efficiency of all factor inputs included in the production.

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2 See Artus and Muet (1990) for a comprehensive overview of the theoretical foundations and econometrical estimation of various factor demand models.
function. Technical inefficiency of the firms in a region may be due to a lack of infrastructure, a shortage of innovational firms, low competitiveness, unfavourable industrial structure, urbanization diseconomies etc. (see Beeson and Husted 1989, Harris 1991b). With production function (1), therefore, it is implied that the same labor and capital input will produce less output in a low efficient region than in a more efficient one.

Firms decide on a certain output increase in period \( t \) and minimize the cost of producing this production increment. From the necessary conditions for labor input and gross investment the cost minimizing condition for factor input in each period \( t \) is obtained as:

\[
\frac{I_t}{\Delta E_t} = g \left( \frac{w_t}{c_t} \right)
\]

(2)

where \( w \) is the real wage rate and \( c \) represents the real user cost of capital. This condition for cost minimization refers, in the putty-clay technology, to the capital intensity of the last vintage only and not the entire existing capacity. Capital embodied in the last equipment generation corresponds then to the realised gross investment in the period \( t \). Combining (1) and (2), desired investment and labor demand are given by:

\[
I_t = I(\Delta Y_t, (w/c)_t, \text{TE})
\]

(3)

with \( \Delta I_Y > 0, I_{w/c} > 0, I_{\text{TE}} < 0 \) and

\[
\Delta E_t = \Delta E(\Delta Y_t, (w/c)_t, \text{TE})
\]

(4)

with \( \Delta E_{\Delta Y} > 0, \Delta E_{w/c} < 0, \Delta E_{\text{TE}} < 0 \). There is one striking property in this factor demand model: Investment and also changes of employment do not depend on changes in the capital-labor cost ratio, as is the case in a factor demand model based on a putty-putty production technology. With a putty-clay production function it is the level of the input cost ratio which produces a change in capital and employment (Artus and Muet 1990, 91f). The impact of TE should be negative in both factor demand equations: higher technical efficiency reduces capital and labor input needed to produce a given output. But this is true only if production remains constant. Higher efficiency also lowers factor costs which leads to higher output growth and this, in turn, increases factor demands (Moomaw and Williams 1991). To capture this latter effect an additional equation is needed which links technical efficiency to regional growth. Such an equation is also necessary to model the output effect of factor price changes because, apparently, equations (3) and (4) can only take account for their substitution effects.

2.2. Output and technical efficiency

The regional output equation contains demand-side as well as supply-side aspects. According to the putty-clay model \( \Delta Y_t \), the desired gross increment

\[\text{footnote}{\text{3}}\]
to capacity in period $t$ has to be explained, that is production based on new capacity corresponding to the difference between total output before and after installation of new plants in period $t$ and on old capacities depreciated in the former period $t - 1$:

$$\Delta Y_t = Y_t - (1 - d_Y) Y_{t-1}$$  \hspace{1cm} (5)

with $d_Y$ the salvage rate. The decision of the firms about the level and location of this increase in production capacity, both for expansion and replacement, depends upon production and cost conditions and demand factors.\(^4\)

The regional cost conditions are given by the real wage rate $w$ and the user cost of capital $c$. As has been shown by Faini and Schiantarelli (1985), the location of new production capacities depends upon an interregional comparison of input prices. They are attracted by those regions where comparative cost advantages prevail. Thus, to allow for interregional cost effects, the inclusion of the factor prices in other regions into the relationship for explaining regional output, besides the local factor prices, is also justified.\(^5\) The regional production conditions can be represented by the availability of infrastructure capital and qualified labor, by agglomeration economies and the innovation potential of the region etc. All those ‘environmental’ factors contribute to a higher productivity of labor and capital and can, therefore, be captured by the technical efficiency variable TE.

The demand factors affecting the regional allocation of changes in capacity output are represented by a regional-specific labor income variable LI and the national capacity utilization rate $U$ in the manufacturing industry. LI captures the influence of regional demand on output. It represents the purchasing power of a region and serves to take into account the counteracting effects of wages: a high regional wage level might deter new plants because of high production costs but also attract them because of high demand potential. In addition, a high wage level in a region can be viewed as an indicator of highly qualified labor and therefore may influence location decisions of the firms positively. With the utilization rate $U$ global demand effects on regional capacity expansion and replacement can be be taken into account.\(^6\) Clearly, in a recession less national capacities are available to be allocated between regions. Finally, because manufacturing output is mainly sold on national markets, global economic conditions will influence regional capacity changes.

Under consideration of definition (5) we can summarize the output equation in the case of no cross-regional cost effects in the following general form:

$$\Delta Y_t = \Delta Y(w_t, c_t, TE, LI_t, U_t, Y_{t-1})$$  \hspace{1cm} (6)

with $\Delta Y_{w_t}, \Delta Y_{c_t} < 0$ and $\Delta Y_{TE}, \Delta Y_{U_t}, \Delta Y_{LI_t} > 0$. When interregional effects are present, factor prices in the other regions have to be included as additional

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\(^4\) The following considerations draw primarily on Faini and Schiantarelli (1985), Bradley and Fitzgerald (1988) and in addition on Crow (1970), Nadj and Harris (1984), and Plaut (1984).

\(^5\) The inclusion of cross-regional cost effects in the output equation does not alter the specification of equation (3) and (4), because the factor demand decisions for a given output depend on the local factor prices only (Faini and Schiantarelli 1985).

\(^6\) Equations defining national instead of regional output in dependence on world instead of national output are derived formally by Bradley and Fitzgerald (1988).
determinants in equation (6) for which we expect positive effects on regional growth \( \Delta Y \). In (6) the yearly change in output is the dependent variable while the former period output appears on the right hand side as an explanatory variable for which, according to (5), a negative signed coefficient \( d_Y \) is expected. The rationale for this is that the capacity output of a region in the current period is largely fixed by plants established in former periods. Once a firm is localised in a region, it will produce there probably for a longer time. When the locational conditions deteriorate relative to other regions, a firm will be shut down and reestablished in another region but not until the production advantages there compensate closure expenses. The formulation of the output equation in (6) is thus in full accordance with the philosophy of our putty-clay factor-demand model.

A main feature of our approach is the inclusion of technical efficiency as a determinant of regional factor demand and growth. Technical efficiency can be viewed as a measure that distinguishes between efficient and inefficient production conditions. A region produces efficiently if for given inputs the maximal possible output is produced. It is technically inefficient if the output is lower for given inputs than that in a technically efficient region. The relative productivity or technical efficiency of a region can then be measured by the relation of a region’s output to the output of the technically efficient region.²

Differences in the regional technical efficiency have been well documented by several authors.³ The estimates of technical efficiency for the most inefficient regions are about 0.5 of the most efficient regions in all studies. This implies that it is necessary to double the inputs of all factors to produce the same output as the most efficient regions. If we think about the factors determining the differences in technical efficiency several causes come to mind. Some of them have already been named in the discussion around equation (1). Taken together the regional differences are influenced by a large number of factors, such as regional industrial structure, labor force characteristics, the structure of the regional capital stock, regional potential for innovation and the spatial arrangement of production, which may lead to agglomeration economies.⁴

2.3. Measuring the user cost of capital

The user cost of capital is a key element in our model. It is of crucial importance since all instruments of regional policy enter the user cost which in turn influences factor demand and output decisions. For the German case the user cost of capital can be defined as:

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² In practice the efficient output is measured as the “best-practice” output in a given sample using methods for estimating “frontier-production functions”. A discussion of several methods for estimating frontier production functions, including econometric and mathematical programming techniques (Data Envelopment Analysis, DEA) and measures of relative efficiency can be found in Fried et al. (1995).

³ Compare for example Carlino and Voith (1992) and Beson and Husted (1989) for the USA and Schalk, Untiedt and Lüschow (1995) for West Germany and the literature cited there.

⁴ Similar enumerations can be found in Carlino and Voith (1992), Moomaw and Williams (1991) and Beson and Husted (1989).

⁵ See Schalk and Untiedt (1995) for the derivation of this formula and for more details regarding the policy instruments.
\[
e^e = \frac{1 - g_1^e - g_2^e - (1 - g_3^e)u^e z^e}{1 - u^e} (i + \delta^e) q
\]

\(g_1\) and \(g_2\) are the rates of the capital investments bonus and the investment grant, respectively. The rates have been distinguished in the underlying observation period 1978–1989 by different types of investment and location (various type of growth centres) and have ranged from 8.75 to 10% for the capital investment bonus and 5 to 15% for the investment grant. The investment bonus is a tax free capital grant and can be treated, as in (7), like an investment tax credit, which is not deducted from allowable depreciation, unlike the investment grant, which must be taxed. Taxation can occur indirectly by deducting the value of assistance from allowable depreciation, thus increasing taxable profits. That is what is assumed in (7) and so \(g_2\) appears in the formula also in connection with \(u^e\).\(^{11}\) The tax rate \(u\) is made up of a weighted average of the global tax rates for distributed and non-distributed profits and a special local business tax which varies regionally due to differing rates of assessment among the communities. In the ‘Zonal Border Area’, an approximately 40 kilometre wide belt of territory along the borders with the former GDR and Czechoslovakia, accelerated depreciation allowances were granted, which means that, in addition to standard straight-line depreciation, 50 percent of the value of an asset could be depreciated within five years after purchase of the investment good. In (7) this leads to varying present values of tax depreciation allowances \(z\) between the Zonal Border Area and the rest of West Germany. \(i\) is the nominal after tax discount rate\(^{12}\), \(\delta\) the economic depreciation rate which varies between regions because of differing regional ages of capital; and \(q\), is the price index of investment good.

Figure 1 shows how the user cost of capital is affected by all three regional policy instruments taken together (capital investment bonus, capital grant and accelerated depreciation allowances). Depending on the type of growth centre\(^{13}\), the reduction in the user cost of capital for regions outside the Zonal Border Area ranges between 14 and 23% and within the Zonal Border Area between 20 and 34%. Thus there are considerable differentials in the user cost of capital between assisted and non-assisted areas, on the one hand, and also between the Zonal Border Area and other assisted areas in Germany, on the

\(^{11}\) The investment grant can also be taxed as a sundry revenue. However, this is normally less profitable for the investor than taxation in the way described in the text above, if interest rates are positive.

\(^{12}\) Harris (1988, 257) has justified the use of a nominal instead of a real interest rate in the user cost of capital definition. Further, regional inflation cannot be calculated because regional price indices are not available, but an interest rate net of global inflation in the user cost has scarcely any effect on the empirical results. A nominal interest rate has also been used in the discounting of the tax depreciation allowances. An increase in the inflation rate will therefore reduce \(z\), thus increasing \(e\). This negative effect of inflation on investment has been much noted in the discussion of supply side economics; see Hulten (1984).

\(^{13}\) The classification as a growth centre in an assisted area follows from the theory of growth poles. In Germany different kinds of growth centres were defined. A and E growth centres lie inside the Zonal Border Area and are areas with overriding importance (A) or are located close to the border (E). B growth centres are also areas with overriding importance but lower incentive intensities. Finally areas classified as C are ordinary growth centres. Because this classification has always been controversial it was abolished in 1995.
Fig. 1. Reduction of the user cost of capital by regional investment incentives in assisted areas in percent, 1977–1989

other. The reductions were lowest in 1981/82 and from 1988 on when the rates for the investment grant decreased considerably.\footnote{14}

3. Empirical results

The model in (3)–(6) serves as a basis for the derivation of equations convenient for estimation. The data set consists of a panel of time series (1978–89)

\footnote{14 The rates for the capital investment bonus were never changed until the abolishment of this subsidy in Germany 1990.}
of 327 cross-regional units (‘Kreise’, districts of the Federal Republic of Germany) for the manufacturing industry in West Germany. Details concerning the data definition, sources etc. and some descriptive statistics can be found in the appendix. But before estimation, various methodical problems need to be addressed and some approximations have to be made to obtain manageable equations. First, we did not adopt a particular form of the ex-ante production function, instead we assumed that the factor demand and the output equations are log-linear.\textsuperscript{15} Second, $AY$ and $AE$, which are not collected, are to be substituted by measurable variables. In equation (5) a substitute for $AY$ has already been presented. A similar expression for $AE$ gives:

$$ AE_t = E_t - (1 - d_E)E_{t-1} \quad (8) $$

respectively

$$ E_t = (1 - d_E)E_{t-1} + AE_t \quad (8') $$

According to (8'), employment in a period corresponds to employment in the former period minus the amount of labor working on salvaged machines plus labor input required to implement the new installed production capacities $Y_t = (1 - d_T)Y_{t-1}$ at date $t$. Generally, if $AX_t = X_t - (1 - d_T)X_{t-1}$ the logarithmic approximation used is:\textsuperscript{16}

$$ \ln AX_t = \ln d_T + \ln X_{t-1} + (1/d_T)\ln X_t $$

Third, to incorporate cross-regional effects, factor prices of the other regions have to be included in the output equation. Instead of using the factor prices of each other region as an explanatory variable, leading to 652 new coefficients, we used after some experimentations the mean values of the user cost of capital and the real wage rate of all regions for a given year, $\bar{c}_t$ and $\bar{w}_t$, as proxies for factor prices outside a region.

Finally, to incorporate dynamics lagged investment as an explanatory variable has been introduced in the investment function and in the labor demand function. This can be justified, i.e., if delivery of investment is distributed over time and it takes time to incorporate delivered capital into the production process.\textsuperscript{17}

For these reasons, the following log-linear factor demand and output equations were used as a basis for estimation:\textsuperscript{18}

\textsuperscript{15} Since the model is completely log-linear, the estimated coefficients can be directly interpreted as elasticities.

\textsuperscript{16} This approximation is calculated as following: $AX_t = (1 + (X_t - X_{t-1})/(d_T X_{t-1})) d_T X_{t-1} = (1 + z_t) d_T X_{t-1}$. For small $z_t$, which is the case in practice ($X_t - X_{t-1} \ll X_{t-1}$ and $d_T$ not to small) $\ln(1 + z_t) \approx z_t$ applies. Thus, $\ln AX_t = \ln d_T + \ln X_{t-1} + (1/d_T)[(X_t - X_{t-1})/X_{t-1}]$. Writing $(X_t - X_{t-1})/X_{t-1} \approx \ln X_t - \ln X_{t-1}$ the formula in the text results. This approximation can also be used when $d_T$ is negative.

\textsuperscript{17} See Faini and Schiantarelli (1985) and Schiantarelli (1983) for more details. The inclusion of investment in the labor demand function is also convenient if investment is subject to convex and nonseparable adjustment costs; see Dinems and Funke (1994) and FitzRoy and Funke (1994).

\textsuperscript{18} Except for the national capacity utilization rate $v_t$; all other variables in (9)–(11) are regional specific where, again, the index $r$ has been omitted.
\[ \ln I_t = \pi_{01} + \pi_{11} \ln Y_{t-1} + \pi_{21} A \ln Y_t + \pi_{31} \ln \left( \frac{w}{c} \right)_t \]

\[ - \pi_{41} \ln TE + \pi_{51} \ln I_{t-1} + \varepsilon_{1t} \]  

(9)

\[ \ln E_t = \pi_{02} + \pi_{12} \ln Y_{t-1} + \pi_{22} A \ln Y_t - \pi_{32} \ln \left( \frac{w}{c} \right)_t \]

\[ - \pi_{42} \ln TE + \pi_{52} \ln E_{t-1} + \pi_{62} \ln I_{t-1} + \varepsilon_{2t} \]  

(10)

\[ \ln Y_t = \pi_{03} - \pi_{13} \ln w_t - \pi_{23} \ln c_t + \pi_{33} \ln TE + \pi_{43} U_t \]

\[ + \pi_{53} \ln LI_t + \pi_{63} \ln Y_{t-1} + \pi_{73} \ln \pi_t + \pi_{83} \ln \varepsilon_t + \varepsilon_{3t} \]  

(11)

with \( \pi_{52} = (1 - d_E) \), \( \pi_{63} = (1 - d_Y) \) and \( \pi_{51} = (1 - \lambda) \), where \( \lambda \) is an adjustment parameter and \( \varepsilon_{ij} \) with \( i = 1, 2, 3 \) a stochastic term which is assumed to be normally distributed with mean zero and variance \( \sigma^2_{ij} \).

In the factor demand functions the coefficients of the output and technical efficiency variables are restricted to be equal.\(^{19}\) In the output function, real input prices are divided by technical efficiency, emphasising that factor costs measured in efficiency units effect regional allocation of new production capacities. Finally, after some additional manipulations and allowing for short-run dynamics up to lag 3 the equations (9)–(11) can be written in error-correction form as:

\[ A \ln I_t = \pi_{01} + \sum_{j=0}^{3} \psi_{11,j} A \ln Y_{t-j} + \sum_{j=0}^{3} \psi_{21,j} A \ln(w/TE)_{t-j} \]

\[ + \sum_{j=0}^{3} \psi_{31,j} A \ln(c/TE)_{t-j} + \sum_{j=1}^{3} \psi_{41,j} A \ln I_{t-j} \]

\[ - \lambda \left[ \ln I_{t-1} - \pi_{11} \ln \left( \frac{Y}{TE} \right)_{t-1} - \pi_{21} \ln \left( \frac{w}{c} \right)_{t-1} \right] + \varepsilon_{1t} \]  

(12)

\(^{19}\) This restriction results from theory if the production function (1) is of the Cobb-Douglas type and equal to \( AE^nF^pTE \). In this case the long-run elasticities of investment demand with respect to output, technical efficiency and the factor price ratio are calculated from (9) as:

\[ \frac{\pi_{11}}{1 - \pi_{51}} = \frac{1}{\alpha + \beta}, \quad \frac{\pi_{41}}{1 - \pi_{51}} = \frac{1}{\alpha + \beta}, \quad \frac{\pi_{31}}{1 - \pi_{51}} = \frac{\alpha}{\alpha + \beta} \]

Thus, the long-run output and technical efficiency elasticities of investment demand are equal but opposite in sign and correspond to the inverse of the scale elasticity of the underlying production function. This would also be true with a more general form of the production function; see Muet (1990, 48).
\[
A \ln E_t = \pi_{02} + \sum_{j=0}^{3} \psi_{12,j} A \ln \left( \frac{Y}{TE} \right)_{t-j} + \sum_{j=0}^{3} \psi_{22,j} A \ln(w/TE)_{t-j} \\
+ \sum_{j=0}^{3} \psi_{32,j} A \ln(c/TE)_{t-j} + \sum_{j=0}^{3} \psi_{42,j} A \ln I_{t-j} + \sum_{j=1}^{3} \psi_{52,j} A \ln E_{t-j} \\
- dE \left[ \ln E_{t-1} - \pi_{12}^* \ln \left( \frac{Y}{TE} \right)_{t-1} + \pi_{22}^* \ln \left( \frac{w}{c} \right)_{t-1} - \pi_{32}^* \ln I_{t-2} \right] + \hat{e}_{2t}
\]

(13)

\[
A \ln Y_t = \pi_{03} + \sum_{j=0}^{3} \psi_{13,j} A \ln(w/TE)_{t-j} + \sum_{j=0}^{3} \psi_{23,j} A \ln(c/TE)_{t-j} \\
+ \sum_{j=0}^{3} \psi_{33,j} A \ln L_{t-j} + \sum_{j=0}^{3} \psi_{43,j} A \ln Y_{t-j} + \sum_{j=0}^{3} \psi_{53,j} A U_{t-j} \\
+ \sum_{j=0}^{3} \psi_{63,j} A \ln(c/TE)_{t-j} + \sum_{j=1}^{3} \psi_{73,j} A \ln(w/TE)_{t-j} \\
- dY \left[ \ln Y_{t-1} + \pi_{13}^* \ln \left( \frac{w}{TE} \right)_{t-1} + \pi_{23}^* \ln \left( \frac{c}{TE} \right)_{t-1} - \pi_{33}^* \ln L_{t-1} \right] \\
- \pi_{33}^* \ln \left( \frac{w}{TE} \right)_{t-1} - \pi_{33}^* \ln(c/TE)_{t-1} + \hat{e}_{3t}
\]

(14)

where coefficients with an asterisk denote long-run elasticities.\(^{20}\) One feature of the error-correction model is that the adjustment parameter in the labor demand and output equations equals the depreciation rate of employment and output. Besides, this modelling allows the seperation of short-run dynamics from the long-run impacts of the investment incentives, the latter being of most interest for regional policy.

Before turning to the estimation results the time series properties of the variables have to be evaluated. Testing for a unit root with panel data is no easy task, since there is no widely accepted test procedure, as it is the case for univariate time series. We follow Im et al. (1997), who propose tests for dynamic heterogenous panels based on the mean of individual unit root statistics (‘\(t\)-bar-test’). They show that, when the errors of the individual (augmented) Dickey-Fuller regressions (for each region) are serially uncorrelated, and normally and independently distributed across groups, their ‘\(t\)-bar’-test is

\(^{20}\) In theory capacity utilization should have no effect on the level of output in the long run. So it has been excluded from the long-run equation in brackets.
Table 1. Panel Unit Root testing using ‘t-bar’-test. The statistic is calculated as $t = 1/327 \sum_{r=1}^{102} \hat{\epsilon}_r$, where $\hat{\epsilon}_r$ is the $t$-statistic of $\beta$ in (15)

<table>
<thead>
<tr>
<th></th>
<th>DF-Test with constant</th>
<th>DF-Test with constant and trend</th>
<th>ADF-Test with constant and trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln I$</td>
<td>-1.62</td>
<td>-2.34</td>
<td>-3.83</td>
</tr>
<tr>
<td>$\ln E$</td>
<td>-0.93</td>
<td>-0.98</td>
<td>-1.34</td>
</tr>
<tr>
<td>$\ln Y$</td>
<td>-0.92</td>
<td>-1.61</td>
<td>-1.59</td>
</tr>
<tr>
<td>$\ln w$</td>
<td>-2.11</td>
<td>-2.98</td>
<td>-23.33</td>
</tr>
<tr>
<td>$\ln L$</td>
<td>-2.03</td>
<td>-3.46</td>
<td>-8.66</td>
</tr>
</tbody>
</table>

Notes: Critical values for accepting the null hypothesis of a unit root for a one-sided test for DF regressions with constant ($r = 100$ and $t = 10$) at the 5% level is $-1.75$, for DF regressions with constant and trend ($r = 100$ and $t = 10$) it is $-2.34$ (Im, Pesaran, Shin (1997)). Critical $t$-values of the ADF-statistic were calculated according to (5.3) in Im, Pesaran Shin (1997) using their table 4. The critical values for a one-sided test are $-1.282$ (10% level), $-1.645$ (5% level) and $-2.325$ (1% level).

distributed as standard normal for a large number of units and a finite number of time periods.

Table 1 shows the results of ‘t-bar’-tests of Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests of the following regression:

$$A_{zt} = \gamma_{zt} + D_{zt} + \beta_{zt, t-1} + \sum_{j=1}^{p} \gamma_j A_{zt, t-j} + \epsilon_{zt}$$

(15)

where $D_{zt}$ contains deterministic variables: $D_{zt} = \{1\}$ and $D_{zt} = \{1, t\}$. The results vary with the specification of the Dickey-Fuller regressions and tend towards rejection of the null hypothesis of a unit root at least at the 10% level when a trend and additional lags of the dependent variables are included. These additional variables are usually significant, so there inclusion is justified. Taken together, the test statistics indicate stationarity of the variables under consideration. This result may be partially determined by the relatively short sample period.

Following the unit root testing, the equations were estimated using nonlinear least squares. The General-to-Specific strategy was chosen to get a parsimonious representation. Table 2 contains the results of the preferred estimates for the factor demand functions and Table 3 those for the regional output growth equations without and with cross-regional cost effects. The results shown were quite robust to variations of the estimation period. The empirical results for all long-run coefficients have the expected signs. The heteroscedasticity consistent $t$-values are significant for all coefficients at least at the 5% level. The Durbin-Watson statistic for panel data (Bhargava, et al. 1983)
Table 2. Empirical factor demand functions for the manufacturing industry of West Germany, 1978–1989

**Investment equation**

\[
\begin{align*}
\Delta \ln I_t &= -1.016 \ln I_{t-1} + 0.372 \ln Y_t + 0.265 \ln Y_{t-1} \\
&\quad -0.106 \ln I_{t-1} + 0.034 \ln I_{t-2} - 0.357 \ln (w/TE)_{t-1} \\
&\quad -0.173 \ln (c/TE)_{t-1} + 0.133 \ln (c/TE)_{t-2} - 0.332 \ln (c/TE)_{t-2} \\
&\quad -0.310 \ln L_{t-1} - 0.920 \ln (Y/TE)_{t-1} - 0.986 \ln (w/c)_{t-1} \\
&\quad (17.81) \quad (49.81) \quad (9.59)
\end{align*}
\]

\[R^2_I = 0.20 \quad \text{DW-P = 2.05} \quad \text{SEE = 0.2571}\]

**Labor demand equation**

\[
\begin{align*}
\Delta \ln E_t &= -0.064 \ln I_t + 0.153 \ln Y_t + 0.314 \ln E_{t-1} \\
&\quad +0.013 \ln I_{t-1} + 0.026 \ln I_{t-2} + 0.011 \ln L_{t-2} \\
&\quad -0.329 \ln (w/TE)_{t-1} + 0.073 \ln (w/TE)_{t-1} + 0.052 \ln (w/TE)_{t-2} \\
&\quad +0.062 \ln (c/TE)_{t-1} - 0.163 \ln (c/TE)_{t-2} \\
&\quad -0.022 \ln E_{t-1} - 0.653 \ln (Y/TE)_{t-1} + 0.384 \ln (w/c)_{t-1} \\
&\quad (7.46) \quad (6.93) \quad (2.16)
\end{align*}
\]

\[R^2_L = 0.48 \quad \text{DW-P = 2.16} \quad \text{SEE = 0.0279}\]

*Notes: t-statistics in parentheses are heteroscedasticity-consistent estimates (White 1980). \(R^2_I\), coefficient of multiple determination for differenced data, see footnote 21; DW-P, Durbin-Watson statistic for panel data Bhargava et al. (1983); SEE, Standard error of estimates.*
Table 3. Empirical output growth functions for the manufacturing industry of West Germany without and with cross-regional effects, 1978–1989

Without cross-regional effects

$$\Delta \ln Y_t = \begin{align*}
0.340 & \quad -0.038 \Delta \ln Y_{t-1} & +0.407 \Delta \ln (w/TE)_t \\
(9.31) & \quad (2.06) & \quad (9.34)
\end{align*}$$

$$+0.043 \Delta \ln (c/TE)_t$$

$$+0.267 \Delta \ln LL_{t-1}$$

$$+1.150 \Delta U_t$$

$$-0.091 \left[ \ln Y_{t-1} + 0.476 \ln (w/TE)_{t-1} + 0.401 \ln (c/TE)_{t-1} \right]$$

$$-0.948 \ln LL_{t-2}$$

$$R^2 = 0.22 \quad \text{DW-P} = 1.78 \quad \text{SEE} = 0.0635$$

With cross-regional effects

$$\Delta \ln Y_t = \begin{align*}
-0.552 & \quad -0.044 \Delta \ln Y_{t-1} & +0.480 \Delta \ln (w/TE)_t \\
(5.16) & \quad (2.44) & \quad (9.60)
\end{align*}$$

$$+0.098 \Delta \ln (c/TE)_t$$

$$+0.272 \Delta \ln LL_{t-1}$$

$$+0.012 \Delta \ln (w/TE)_t$$

$$+0.966 \Delta U_t$$

$$+0.966 \Delta U_t$$

$$-0.080 \left[ \ln Y_{t-1} + 0.671 \ln (w/TE)_{t-1} + 0.283 \ln (c/TE)_{t-1} \right]$$

$$-0.953 \ln LL_{t-2}$$

$$-0.168 \ln (w/TE)_{t-1}$$

$$-0.098 \ln (c/TE)_{t-1}$$

$$R^2 = 0.24 \quad \text{DW-P} = 2.02 \quad \text{SEE} = 0.0626$$

Notes: See table 2.

indicates no first order serial correlation and the $R^2$ for differenced data ranges between 0.20 and 0.48.\textsuperscript{22}

\textsuperscript{22} We used $R^2$ instead of $R^2$ as a goodness-of-fit measure which can be viewed as a generalisation of a relative $R^2$ for univariate time series suggested by Harvey (1984). It is defined as:

$$R^2 = 1 - \frac{\text{RSS}}{\sum_i \sum_j (\Delta y_{it} - \overline{\Delta y})^2}$$

and compares the residual sum of squares (RSS) of the econometric model with the sum of squares of the first differenced observations about their mean. A $R^2$ near unity can be produced by simply adding the lagged endogenous variables on both sides of the model without changing the RSS. However, as has been shown by Granger and Newbold (1974) this result is of little value. With respect to $R^2$, a model should be discarded if it is negative or equal to zero. Tests that this is the case cannot be obtained for any model at a 1% level of significance.
Table 4. Long-run elasticities

<table>
<thead>
<tr>
<th></th>
<th>Investment substitution effects</th>
<th>Employment substitution effects</th>
<th>Output substitution effects</th>
<th>Productivity substitution effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor price elasticities*</td>
<td>( \frac{\partial \ln I}{\partial \ln w} ) = 0.986 * ( \frac{\partial \ln E}{\partial \ln w} )</td>
<td>( \frac{\partial \ln I}{\partial \ln c} ) = -0.986 * ( \frac{\partial \ln E}{\partial \ln c} )</td>
<td>( \frac{\partial \ln I}{\partial \ln w} ) = -0.100 * ( \frac{\partial \ln Y}{\partial \ln w} ) = -0.671 * ( \frac{\partial \ln I}{\partial \ln c} ) = 0.100 * ( \frac{\partial \ln Y}{\partial \ln c} ) = -0.283</td>
<td></td>
</tr>
<tr>
<td>Output elasticities**</td>
<td>( \frac{\partial \ln I}{\partial \ln Y} ) = -0.920 * ( \frac{\partial \ln E}{\partial \ln Y} ) = 0.920 * ( \frac{\partial \ln Y}{\partial \ln TE} ) = 0.954</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total effects*</td>
<td>( \frac{\partial \ln I}{\partial \ln w} ) = -0.368 * ( \frac{\partial \ln E}{\partial \ln w} ) = -0.715 * ( \frac{\partial \ln Y}{\partial \ln w} ) = -0.140 * ( \frac{\partial \ln I}{\partial \ln c} ) = -1.246 * ( \frac{\partial \ln E}{\partial \ln c} ) = -0.167 * ( \frac{\partial \ln Y}{\partial \ln c} ) = -0.140 * ( \frac{\partial \ln I}{\partial \ln TE} ) = -0.042 * ( \frac{\partial \ln E}{\partial \ln TE} ) = -0.043 * ( \frac{\partial \ln Y}{\partial \ln TE} ) = -1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: * Calculated for given output and taking into consideration the interdependency between investment and labor demand.
** Taking into consideration the interdependency between investment and labor demand.
* The total effects of a one percent change in the user cost of capital on the relative investment change is calculated as follows: \( \frac{\partial \ln I}{\partial \ln w} = \frac{\partial \ln I}{\partial \ln w} + (\frac{\partial \ln I}{\partial \ln Y})(\frac{\partial \ln Y}{\partial \ln w} \cdot (\frac{\partial \ln Y}{\partial \ln c})). \) The other total effects are calculated similarly.

We refrain from discussing the short-run dynamics of factor demand and output growth and confine ourselves to the interpretation of the politically more interesting elasticities. Since the model is estimated with logarithmic variables, the parameter values in brackets in Table 2 and 3 can be directly interpreted as long-run elasticities, however, without taking into consideration the interdependencies between the factor demand equations respective of the factor demand and output equations. (The long-run model elasticities are shown in Table 4). The estimated value for \( \lambda \) in front of the bracket in the investment function (Table 2) implies a mean lag of about 2 which means that adjustment to the desired level of investment has occurred after two years. At least for the adjustment parameters in the growth equations (Table 3), the salvage rate of production capacity, the estimated values of 0.08 and 0.09 respectively are what is expected for the manufacturing industry. We have no indication to suppose that the corresponding value in the labor demand equation (0.022) is too low.

The factor price elasticities of investment demand (0.99) seem to be rather high, compared to the values obtained by Faimi and Schiantarelli (1985) with a similar model for Italy (0.46) and King (1972) with a putty-clay investment function for the UK (0.15). However, in theory, estimates closer to unity are expected and have also been obtained with putty-clay models by
Bischof (1971) for the U.S. and Schiantarelli (1983) for Italy. The positive coefficient shows that lowering the user cost of capital by investment incentives has a significantly positive impact on investment. The estimated output elasticity near unity is in line with most other empirical findings.

Turning to the labor demand equation in Table 2 the most remarkable result is that investment has a positive effect on employment, so that anything that increases investment also increases employment.24 The output elasticity of labor demand near unity is in line with most other empirical findings (Franz and König 1986 and Faini and Schiantarelli 1985). The coefficient of the factor price ratio in the employment function documents that there is a significant substitution effect (absolute value: 0.38). But this parameter value does not show the entire impact of factor price movements on employment for a given output level. Because investment has a positive impact on employment and lower user cost of capital induces higher investment, a complementary relationship exists between employment and capital inputs in equilibrium. Factor prices affect labor demand directly according to the labor demand function and indirectly via capital accumulation according to the investment function. Taking these effects into consideration, the absolute elasticity of labor demand with respect to the factor price ratio is considerably lower than that depicted in Table 2 and as high as presented in Table 4 (0.10 instead of 0.38).25 This elasticity ranks among the lowest of those reported by Hamermesh.26

The estimated long-run elasticities of the output growth equations with and without cross-regional effects in Table 3 look reasonable. Higher wages and higher user costs of capital reduce growth whereas the proxy for regional demand (labor income) has a positive elasticity near unity. In the model with cross-regional effects the average labor and capital user costs, measured in efficiency units \((w/TE)\) and \((c/TE)\), have been included as additional variables to capture the impacts of comparative factor cost levels on regional output growth. The estimated effects have the expected positive signs and are significant at high levels. The inclusion of the cost conditions in all regions leads to remarkable changes in the coefficients of the local factor price variables: the output effect of the wage rate increases and that of the user costs of capital decreases. Thus, the positive impact of regional policy on output growth and factor demand is much lower when the model with cross-regional effects is the correct one. Because this model cannot be rejected at the 1% level of significance when tested against the model without cross-regional effects using a likelihood-ratio test, below the simulation results of the impact of regional investment incentives are based on the output equation with cross-regional effects.

In the lower part of Table 4 the total effects of factor price changes are

---

23 For a Cobb-Douglas production function with constant returns to scale the factor price elasticities of investment demand should correspond to the production elasticity of labor. For this, values between 0.6 and 0.8 were obtained; see Schalk (1976) and Schalk et al. (1995).

24 A similar result was obtained by Funke and Dinenis (1994) for the German manufacturing industry.

25 We also calculated \(t\)-values for these elasticities using the ‘delta-method’ (Greene 1997, 277; Kmenta 1986, 485). They indicate significance at the 10% level \((t = 1.33)\), while in the investment demand equation, the coefficient of the factor price ratio is significant at the 1% level \((t = 9.59)\).

26 See Hamermesh (1986), Table 8.2, p. 452.
made up of the sum of the substitution and output effects. They can be used to evaluate regional policy in West Germany. As expected, the total effects are lower than the factor price elasticities obtained with output held constant. The most striking result, however, is that the elasticity of labor demand with respect to the user costs of capital changes its sign from plus to minus when the output effect of a capital cost variation on employment is taken into account.\footnote{Using the ‘delta-method’ (see footnote 23) the \( \phi \)-value of this elasticity, which is crucially for the overall employment effect of regional policy, indicates significance at the 10\% level for a one-sided test (\( t = 1.26 \)).} This means that the output effect of a change in \( \phi \) on labor demand overcompensates the substitution effect. Put differently, regional investment incentives, reducing the user cost of capital, do not only succeed in inducing additional investment but also create more employment in the assisted areas. By contrast, raising \( \lambda \) increases investment because the substitution effect dominates.

As further evidence of the efficiency of regional investment incentives we estimated the quantitative effects of the capital subsidies paid in each year between 1980 and 1989. To evaluate these, the elasticities of the total effects in Table 4 were used to simulate the values for investment, employment and output if all regional instruments had been excluded. The differences between these values (without regional policy) and those realised (with regional policy) estimate the impact of regional investment incentives. The results are reported numerically in Table 5. The data in the table refer to the effects of the investment incentives granted in the particular year regardless of the years in which they become effective. As can be seen, on average in each year of the time period under observation, regional policy induced DM 2.5 billion additional investment, created for 43 thousand persons employment and increased production capacity by DM 4.8 billion. Put another way, without regional policy investment in all assisted areas would have been 12\% lower, employment 1.6\% and output 2.8\%.

\begin{table}[h]
\centering
\caption{Simulated effects of regional investment incentives in the assisted areas of West-Germany, 1980–1989}
\begin{tabular}{|l|l|l|l|}
\hline
Year & Investment & Employment & Output \\
\hline
1980 & 2308 & 43 & 4330 \\
1981 & 2143 & 43 & 4517 \\
1982 & 1954 & 40 & 4250 \\
1983 & 2067 & 40 & 4383 \\
1984 & 2161 & 44 & 5138 \\
1985 & 2063 & 37 & 4425 \\
1986 & 2718 & 40 & 4685 \\
1987 & 2785 & 43 & 4779 \\
1988 & 3360 & 50 & 5872 \\
1989 & 3473 & 48 & 6021 \\
\hline
Total & 25032 & 428 & 48401 \\
\hline
\end{tabular}
\end{table}

Fig. 2. The output per capita ratio in the manufacturing industry, 1980–89, real output per capita in the assisted areas = 100 in 1980

The assistance volume of all three investment incentives (investment bonus, investment grant and accelerated depreciation allowances) amounted up to DM 1.1 billion yearly between 1980 and 1989. This implies that every DM of regional subsidies stimulated DM 2.3 additional investment in the manufacturing industry of the assisted areas which would not have occurred in the absence of regional incentives. It also means that per incremental job approximately DM 25,000 has to be met by regional policy. These costs are considerably lower than the yearly costs of an unemployed person which amounted up to DM 29,000 in 1989. Hence, also from these figures it can be stated that regional policy in West Germany has been quite effective with respect to both its investment and employment target.

What remains is the question of whether regional policy also succeeded in its equity target, that is, if it was able to increase significantly per capita income in the assisted areas, thus leading to a reduction in interregional income differences. If measuring the regional income target by output per employee or labor productivity is accepted, an answer can be given using Fig. 2. It shows that the impact of regional investment incentives on labor productivity in the assisted areas is nearly negligible. Moreover, traditional investment incentives do not seem to be able to contribute to a reduction in interregional productivity differences in the manufacturing industry. In the sample period regional policy has even failed to prevent increasing divergence between ‘poor’ and ‘rich’ regions. But it has to be reiterated that these simulation results have been achieved under the assumption of constant technical efficiency, that is, technical efficiency is not affected by regional policy. Table 4 shows, that per capita output is mostly influenced by technical efficiency. Because the low-income regions are also the least efficient ones a regional policy promoting technical efficiency seems to be a necessity for reducing interregional income
differences. This is in keeping with recent growth empirics, which stress the role of differences in technologies across countries in explaining the lack of convergence of labor productivity.\textsuperscript{28}

4. Conclusions

The main topic of this paper has been an econometric analysis of the impacts of regional investment incentives on manufacturing investment, employment and output in the assisted areas of West Germany. In order to consider short-run dynamics and long-run equilibrium simultaneously, an error correction model has been estimated. Technical efficiency, a topic which has received attention recently in regional growth theory has been included in the model explicitly and proved to be an important determinant in regional factor demand analyses.

The model distinguishes between substitution and output effects of input price changes on factor demands. In contrast to regional impact analyses for other countries we could not find evidence that the substitution effect outweighs the output effect and, therefore, instead of creating employment, regional policy displaces labor, though it succeeds in inducing additional investment. For instance, Faini and Schiantarelli (1985) determined for Italy that scale and substitution effects cancel each other out and Harris (1991a) for Northern Ireland and Luger (1984) for U.S. regions estimated the substitution effect to be larger than the output effect so that employment is negatively influenced by regional investment incentives. Our results are more in line with those of Daly et al. (1993) for the Cape Breton region in Canada. However, the relatively low employment effect they found ‘suggests that tax incentives for capital investment may not be the most effective way to stimulate employment in the region’ (Daly et al. 1993, 571).

In summary, our results provide empirical evidence that regional investment incentives in Germany, unlike in other countries, has had success with respect to both the investment and employment target. However, it remains an open question whether this policy is also efficient with respect to its income convergence target. Further investigations are necessary to determine whether regional policy leads also to a significant improvement in technical efficiency, a major determinant of regional income per capita. This question could be answered using a model with technical efficiency endogenized. The development and empirical implementation of such an endogenous growth model will be the focus of future work.

Appendix

This appendix contains some information on data sources, definitions etc.

All data are for the manufacturing sector of the West-German economy for the period 1978 to 1989 and the cross-section units Kreise (n = 327, West-

\textsuperscript{28} The importance of technology for labor productivity convergence is brought out theoretically and empirically by Bernard and Jones (1996).
Berlin was excluded) so that the data set consists of 3,924 observations. The main statistical sources are the statistical reports EI1, EI4, EI6 and the ‘Gemeinschaftsveröffentlichung der Statistischen Landesämter’, various issues.

The variables used are defined as follows:

\( E \) number of persons employed, mean value per year in thousand persons.
\( I \) real gross investment, obtained by dividing gross investment at current prices by the investment deflator \( q \) at the national level, in mill. DM.
\( Y \) real value added, obtained by dividing gross value added at current prices by the output deflator \( p \) at the national level, in mill. DM.
\( LI \) real labor income, obtained by dividing gross labor income at current prices by the output deflator \( p \) at the national level, in mill. DM.
\( w \) real labor income per man (cost per man), obtained by dividing \( LI \) by \( E \), in 1000 DM.
\( c \) real user cost of capital, calculated according to equation (7), in DM per 100 DM capital. To save space the calculated numbers for the instruments that influence the user cost of capital for each region and year are not enclosed. They are available on request.
\( TE \) technical efficiency of regional production defined as \( e^{-\tilde{v}_r} \). \( \tilde{v}_r \) was calculated as follows: Time series cross-section data for the period 1978 to 89 were used to calculate ‘frontier production functions’:

\[
\ln Y_{rt} = A + \alpha \ln E_{rt} + \beta \ln C_{rt} + \epsilon_{rt} - v_r
\]

with \( C \) as the capital stock in region \( r \) and \( E(\epsilon_{rt}) = 0 \) and \( v_r \geq 0 \). Using

\[
A + \bar{\epsilon}_{rt} - v_r = \ln Y_{rt} - \tilde{\alpha} \ln E_{rt} - \tilde{\beta} \ln C_{rt}
\]

an estimate of the regional level of technology follows as:

\[
\bar{A}_r = \frac{1}{T} \sum A + \bar{\epsilon}_{rt} - v_r
\]

The ‘best-practice’ technology is given by:

\[
\bar{A}_0 = \max(\bar{A}_r).
\]

Estimates for \( v_r \) result from:

\[
\bar{v}_r = \bar{A}_0 - \bar{A}_r.
\]

Details can be found in Schalk et al. (1995).
Regional investment incentives in Germany

Table A. Descriptive statistics \( n = 327 \) 'Kreise'

<table>
<thead>
<tr>
<th>1978</th>
<th>1989</th>
<th>growth rate per year in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean</td>
<td>mean</td>
<td>standard deviation</td>
</tr>
<tr>
<td>( E ) in 1000</td>
<td>22.63</td>
<td>24.44</td>
</tr>
<tr>
<td>( I ) in mill. DM</td>
<td>134.63</td>
<td>173.08</td>
</tr>
<tr>
<td>( Y ) in mill. DM</td>
<td>1,409.19</td>
<td>1,762.24</td>
</tr>
<tr>
<td>( Y/E ) in 1000 DM</td>
<td>60.73</td>
<td>21.30</td>
</tr>
<tr>
<td>( I/Y ) in %</td>
<td>10.10</td>
<td>4.4</td>
</tr>
<tr>
<td>( LI ) in mill. DM</td>
<td>865.85</td>
<td>1,070.53</td>
</tr>
<tr>
<td>( w ) in 1000 DM</td>
<td>35.09</td>
<td>4.82</td>
</tr>
<tr>
<td>( c ) in DM</td>
<td>7.22</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Notes: 
**a)** calculated as \( 1/327 \sum_{t=1}^{327} (Y/E)^t \).
**b)** calculated as \( 1/327 \sum_{t=1}^{327} (I/Y)^t \), for \( t = 1978 \) and \( 1989 \).

Table B. Descriptive statistics

<table>
<thead>
<tr>
<th>TE, technical efficiency in %</th>
<th>(time invariant and regional variant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean</td>
<td>standard deviation</td>
</tr>
<tr>
<td>70.0</td>
<td>11.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>U, national utilization rate in %</th>
<th>(time variant and regional invariant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean</td>
<td>standard deviation</td>
</tr>
<tr>
<td>83.4</td>
<td>2.3</td>
</tr>
</tbody>
</table>

References

Crow RT (1979) Output determination and investment specification in macroeconomic models of open regions. Regional Science and Urban Economics 9:141–158


Scharff R (1993) Regionalpolitik und regionale Entwicklungspotentiale. Campus Verlag, Frankfurt