Kopp, Andreas

Working Paper

Public sector capital and labour productivity: West German federal states and spatial interdependence

Kiel Working Papers, No. 699

Kieler Arbeitspapiere
Kiel Working Papers

Kiel Working Paper No. 699

Public Sector Capital and Labour Productivity

West German Federal States and Spatial Interdependence

by Andreas Kopp
July 1995

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

ISSN 0342 - 0787

The Kiel Institute of World Economics
Düsternbrocker Weg 120
D-24100 Kiel
Federal Republic of Germany
Tel.: (431) 8814-230
Fax.: (431) 8814-500
e-mail: akopp@ifw.uni-kiel.d400.de

Kiel Working Paper No. 699

Public Sector Capital and Labour Productivity

West German Federal States and Spatial Interdependence

by Andreas Kopp
July 1995

1. Introduction

The perception of the importance of public expenditures has undergone a remarkable change For long in the post-war period the discussion had focused on the consumption benefits accruing from public expenditures. More recently, public investment has been emphasised as a means to trigger private investment and to foster the macroeconomic performance in general. More specifically, the assertion that high levels of public investment in lagging regions are conducive to levelling interregional productivity differentials has been of major importance in regional policy discussions. Not least, it looms large in economic policy debates on how to bridge the income and productivity gap between East and West German federal states.

The question that is addressed in this paper is not whether these claims can generally be justified. Rather, the paper tries to give an answer to the question whether the experience of the West German federal states during the seventies and the eighties support the hypothesis that the size of the public sector capital stock has positively influenced labour productivity. Related studies based on US. state level data investigating the relationship between (regional) economic growth and public investment have come up with conflicting results while studies using disaggregated data on West German manufacturing industries found a positive relationship between public sector capital accumulation on the one hand and private capital accumulation and manufacturing production on the other. From this an instrumental role of public investment for regional competitiveness is inferred.

In this paper these findings are re-examined, using a production function approach, and without confining the analysis to the effects of public sector capital on the manufacturing sector. It is based on the regional accounts of the West German Länder over the period 1970 to 1991 (cf. Appendix A on a detailed description of the data). The results of the analysis cast doubt on the validity of the far reaching conclusions that have been drawn from previous investigations of the relationship between regional public investment and regional growth.

In what follows I shall review the growth theoretic background, the "public infrastructure debate" and present a broad picture of the East-West gap in the German economy, giving background to the importance for actual economic policy debates in Germany. In section three the methodological issues that have played a major role in previous empirical studies on the relationship between public sector capital and regional productivity will be discussed before turning to what has been found out on that relationship using the cross section of the regional account time series of the German Federal States.

2. Background of the Public Sector Capital Debate

The greater importance that is assigned to public investment as a policy instrument to foster economic growth is related to two historical phenomena. First, the secular weakening of the increase of labour productivity since the seventieth in the OECD countries was attributed to a decrease in public sector capital formation (Ford/Poret 1991) and second the need to reconstruct the former socialist countries motivated an intensified infrastructure research. Part of the latter is the discussion on public capital requirements for the Eastern Federal States in Germany.

The question whether too low a level of public capital formation was responsible for a slow productivity growth was extensively discussed in the U. S. The U. S. Congress installed a National Council on Public Works Improvement in 1984 which rated the level of public investment expenditures as grossly inadequate, stating that "... the quality of America's infrastructure is barely adequate to fulfil current requirements and insufficient to meet the demand of future economic growth and development." In July 1989 there has been a hearing before the Joint Economic Committee of the Congress of the United States on the *under*investment in infrastructure ('Public Investment in Human and Physical Infrastructure', Joint Economic Committee, Congress of the United States, July 1989).

What the specific German situation is concerned, given the dismal state of the public infrastructure inherited from the German Democratic Republic there was no doubt that the lack and the poor quality of public sector facilities were a major bottleneck to rapid economic growth in the East German Bundesländer (Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung 1990/91, pp. 81-82; Schrumpf

1992). Some estimates of the financial requirements for public investment in East Germany were justified not by the expected growth effects but by the mere gap between public sector capital stock figures per head for the West and East German Bundesländer (DIW 1991, 1994, Vesper 1993). Others stated explicitly the expectation of strong growth effects of public sector investments beyond the catching up with West German per capita values (McDonald/Thumann 1990). The Ministry of Economic Affairs saw public infrastructure investments as a key instrument to promote East German growth in the medium and long term perspective (BMWI 1992). Forecasts of the investments up to the year 2000 are based on the assumption that the level of public sector investments should and will maintain the 1993 level, that is an annual volume of about DM 23 billion in constant prices. (DIW 1994). At the end of the decade the per worker level of public sector capital stock would reach then about 80 per cent of the West German level.

Parallel to the greater attention public sector capital received in economic policy discussions the role of public investment expenditures was emphasised in the growth theoretic literature and empirical studies of recent years.

Early theoretical studies examining the role of public policy in generating long-run growth (e.g. Jones and Manuelli (1990), King and Rebelo (1990), and Rebelo (1991)) abstracted from any influence that government expenditures could have on households' preferences or on production technology. Public expenditures and tax rates in these models were assumed to be exogenous. Barro (1990) developed a simple and elegant model of endogenous growth in which the government uses tax revenue to finance government expenditure which enters the production function as a productive input. The public service is assumed to be rival and excludable. In this model each producer had property rights to a specified quantity of public services. As the public services are rival and excludable no individual producer can trespass on or congest the services provided to others (cf. also Jones, Manuelli and Rossi (1993)).

Barro/Sala-i-Martin (1992) added another version of a growth model with public services and taxes assuming that the public services are of a Samuelson (1954) style, i.e. non-rival and non-excludable goods. Instead of using the level of public services per producer as an argument of the production function in intensive form they used the aggregate government purchases of investment goods.

Assuming constant returns to scale with respect to the private inputs the aggregate production function has the following form:

$$Y = AK^{1-\alpha}L^{\alpha}G^{\beta},$$

with Y denoting gross domestic product, K private capital stock, L labour input, G public capital stock, and $(1-\alpha)$, α and β the output elasticities, respectively. That is, it is assumed that there are increasing returns with respect to all inputs. Looking at the labour productivity as a function of capital intensity they obtained as the production function in intensive form

$$y = Ak^{1-\alpha}G^{\beta},$$

with y denoting gross domestic output per worker, k private capital stock per worker and G the stock of public capital. The government chooses the optimal public policy by maximising the representative household's welfare. They showed that if the technology exhibits constant returns to the reproducible factors (aggregate stock of infrastructure and the amount of private capital rented by the representative firm) optimal public investment policies imply sustained growth in per capita income.

Empirical investigations of the influence of public sector investments on *regional* growth have to some extent been provoked by studies on the hypothesis that public sector capital is a potent force behind macroeconomic performance. Almost all of the studies using national data found a positive relationship between growth and public sector capital (cf. the review of Hakfoort 1993) This was ascertained regardless of whether a production function, a profit function or a cost function approach was chosen for specifying the econometric model.

The use of national data in studies on the relationship for the United States of America has been criticised on the grounds that these data contain essentially a single observation: The concomitant slowdown in productivity growth and public sector capital accumulation in the early seventies (Holtz-Eakin 1994). The observed pattern also of other post-war macroeconomic series of quantities might suggest just the opposite interpretation to the one that is usually attached to it: Deteriorating macroeconomic conditions might have led to the slowdown of public sector capital accumulation. If this criticism is valid data of sub-national levels appear to be the most promising source of information on the growth and productivity effects of public sector capital.

However, results of the studies using regional data have come up with less unambiguous results: Studies at the regional and metropolitan level generally find elasticities of lower magnitude. this has been interpreted as indicating that low values of output or productivity elasticities should be attributed to a higher level of regional disaggregation. (Hakfoort 1993, Holtz-Eakin 1994). The reduced importance of public sector capital for growth was traced back to inter-regional spillovers of public capital[1]. Munnell (1990b) and Garcia-Mila/Mc Guire (1992), however, found public sector capital to have an important role in explaining differences in the regions' economic performance. Hulten and Schwab (1978,1991), focusing on regional growth accounting found that the residual not accounted for by private inputs was at odds with regional pattern of public sector investment.

The differences of the results of the regional studies have been held to be due to a neglect of unobserved, region or state specific characteristics. On a priori grounds it is expected that more prosperous regions spend more on public capital and that therefore there well be a positive correlation between the region-specific effects and public sector capital. This has led to the assertion that erroneously productivity increasing effects are attributed to public capital that in fact are due to unobserved region- or state-specific factors.

For the aggregate of West Germany (Seitz 1994) and using data from the level of the individual West German states (Seitz and Licht 1993) a strong positive relationship between public capital and productivity has been identified. In both of these studies a cost function approach is used examining the impact of public capital on the private economy by estimating a generalised cost function introducing public capital as a fixed

---

1 Munnel, however, argued exactly the opposite: Evidence be consistent with the expectation that the estimated coefficient of the influence of public capital on per capita income should rise with the level of disaggregation. The higher the level of aggregation the more one misses a fraction of the spillover benefits from the public capital stock. Hence estimates using lower level regional data should show a greater role for public sector capital.

unpaid factor. In both cases the analysis was confined to the private manufacturing sector. The study on West Germany as a whole was based on data of 31 two-digit industries for the period 1971-1989. The study using German state level data did assume fixed state level effects. Seitz and Licht draw strong policy conclusions from their findings: "With regard to regional development policy, investing in public infrastructures can be considered to be an instrument to improve the competitiveness of cities, regions and nations. Regional governments can increase the attractiveness of their region by providing more and better quality stock of cost-reducing infrastructure." (Seitz and Licht 1993, p. 129) If this were a generally valid conclusion it would provide a strong argument for those who see public sector capital accumulation as a key to the growth perspective of East Germany and claim that higher levels of public investment expenditures are called for rather than a reduction that is postulated presupposing that the absorptive capacity is overdrawn in the East German federal states.

In this paper the experience of the West German federal states is re-examined using a production function approach without confining the analysis to the manufacturing sector. The relationship between labour productivity and public capital is analysed contrasting the results of a panel data analysis assuming that the processes of capital accumulation and growth in the individual states are independent of each other and the Seemingly Unrelated Regression Analysis of the relationship taking account of spatial interdependencies by introducing spatial autocorrelation across neighbouring states. Both is based on the time series of cross-sections of the eleven West German federal states for the years 1971 to 1991.

3. Conceptual Issues

The centrepiece of the analysis is an aggregate production function pertaining to the West German federal state of the form

$$q_{st} = \beta_0 + \beta_1 k_{st} + \beta_2 c_{st} + \beta_3 G_{st} + \varepsilon_{st} \tag{1}$$

where s indexes states, t time periods, q_{st} is the logarithm of gross domestic product per worker, k_{st} is the logarithm of private capital inputs per worker, c_{st} is private structures per worker and G_{st} is the logarithm of public sector capital. The basic issue is whether β_3 is positive and, if so, whether it is quantitatively important.

The discussion of equation (1) centres around the specification of the econometric error. The error term is typically specified as

$$\varepsilon_{st} = f_s + \gamma_t + \mu_{st} \tag{2}$$

where f_s is a state specific component, γ_t is a time specific component, and μ_{st} is a i.d.d. error.

The time specific effects γ_t control for shocks to the production function that are common to all states in each time period. They control primarily for business-cycle effects on productivity. A state production function, being specified as equation one under the assumption that the ε_{st} are i.i.d. errors would ignore the state specific effects of land area, location, weather, endowments with natural resources and other factors that result in differential productivity across locations.

A first step in estimating the productivity effects of public capital using regional data consists of checking the results of a panel data analysis assuming that the state related effects are unimportant or whether state effects have to be considered fixed or random.

Introducing fixed effects for the individual states as state dummies makes inferences conditional upon a particular set of f_s. The resulting analysis ignores information from cross-state variation in the variables, focusing on time variation within each state. For this reason Garcia-Mila and Mc Guire (1992) refuse to include state dummy variables.

Alternatively, the state effect may be considered random, as a component of the error term. The random effects specification would allow for retaining the cross- state information in the sample. However, the presence of the f_s then implies a correlation between the error term common to each state, requiring a generalised least squares estimator. What is reported below as the random effects estimation has been obtained using a GLS estimator, assuming that the error terms are independent. Moreover, if state effects and the right hand side variables are correlated, the GLS estimator will be biased and inconsistent. A correlation between the right-hand side variables and the state effects may arise if levels of private and public inputs are chosen conditional upon the state-specific effect. Only the fixed effects estimator will provide consistent estimates under these circumstances but, as noted above, will only exploit the "within-state" or time variation in the data.

A further source of potential bias and inconsistency is the possible simultaneous determination of observed quantities of capital, labour and output. This type of correlation (between input data and μ_{st}) would render conventional fixed effects estimators biased and inconsistent (Nickell 1981).

In this paper it is proposed to take account of possible interregional spillovers by estimating the relationship between labour productivity on the one hand and private capital per head and public capital on the other by a spatial seemingly unrelated regression model with spatial error autocorrelation (cf. the extensive discussion in Chapter 10 of Anselin (1988)). The spatial SUR model is meant to contribute to an answer to the question to what extent spatial spill-over effects influence the estimates of the productivity effects of public capital and to solve the problems of the correlation between the state effects and the exogenous variables as well as the potential bias and inconsistency of the fixed effects estimator.

The spatial SUR model consists of an equation for each time period which is estimated for the cross-section of regional units, here the West German federal states. For each of these equations it is assumed that there is a spatial dependence between each of the contiguous regional units. The spatial dependence may be due to two broad classes of conditions: The first is a by-product of measurement errors which usually derive from the fact that there is possibly little correspondence between the spatial scope of the phenomenon under study and the delineation of the spatial units of observation. As a consequence, measurement errors will tend to spill over across the boundaries of the spatial units. This spatial spill-over in measurement errors is one obvious cause for the presence of spatial dependence.

The second factor which may cause spatial dependence is more fundamental and follows from the importance of location-related omitted variables that shape economic decisions.

As a result, what is observed in one point in space may be determined by what happens at other points. This implies dependence between phenomena at different locations in geographical space.

The simplest form of accounting for spatial dependence, which is applied here, is to assume a spatial autoregressive disturbance. For the yearly equations

$$q_t = \beta_0 + \beta_1 k_t + \beta_2 c_t + \beta_3 G_t + \varepsilon_t \tag{3}$$

we assume, abstracting from state and time effects for the moment, that

$$\varepsilon_t = \lambda_t . W . \varepsilon_t + \mu_t , \tag{4}$$

with $E[\mu_t . \mu_s '] = \sigma_{ts} I$.

W denotes a binary contiguity or connectivity matrix implying the hypothesis that spatial dependence exists only between neighbouring regional units or federal states, respectively. λ_t denotes the (time-specific) spatial autoregressive coefficient. The corresponding error variance is of the form

$$\Omega_t = E\left\{\left[(I - \lambda_t W)^{-1} \mu_t\right]\left[(I - \lambda_t W)^{-1} \mu_t\right]'\right\}$$

or (5)

$$\sigma_t^2 \Omega_t(\lambda_t) = \sigma_t^2 (I - \lambda_t W)^{-1} . \left[(I - \lambda_t W)^{-1}\right]' .$$

Consequently, the variance associated with ordinary least squares estimates for the coefficients of the model will be a complex function of the parameter λ_t. Therefore, even though the OLS estimate retains unbiasedness, it will be inefficient. If the error covariance is known, the Best Linear Unbiased Estimator is the Aitken Generalised Least Squares. In terms of the model of equation (4) this means that both the structure of the spatial dependence, the matrix W, as well as the associated autoregressive coefficient λ_t have to be known.

The Estimated Generalised Least Squares procedure used here consists of an application of the GLS principle with consistent estimates for the parameters in Ω_t substituted for the unknown population values. This EGLS procedure is numerically equivalent to OLS estimation on suitably transformed variables X_t^* and q_t^* with

$$X_t^* = (I - \lambda_t W) X_t \text{, and} \tag{6}$$

$$q_t^* = (I - \lambda_t W) q_t . \tag{7}$$

X_t denotes the matrix of input coefficients of spatial units of period t and q_t as above the corresponding output vector. As mentioned above, W is assumed to be a binary contiguity matrix. λ_t is estimated by a Hildreth-Lu grid search procedure (Hildreth/Lu 1960).[2] For the search procedure λ_t is initially assumed to take on the values -0.9 to 0.9 The coefficient which leads to the lowest residual sum of squares is then chosen and around that value the lowest RSS is identified for steps of 0.01.

To make use of the time series information the estimated equations for the individual years are stacked to form a combined regression model with the subscripts referring to time periods:

$$\begin{pmatrix} q_1^* \\ q_2^* \\ \cdot \\ \cdot \\ \cdot \\ q_m^* \end{pmatrix} = \begin{bmatrix} X_1^* 0 \ldots 0 \\ 0 X_2^* \ldots 0 \\ \\ \\ \\ 0\, 0 \ldots X_m^* \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \cdot \\ \cdot \\ \cdot \\ \beta_m \end{bmatrix} + \begin{bmatrix} \mu_1 \\ \mu_2 \\ \cdot \\ \cdot \\ \cdot \\ \mu_m \end{bmatrix} \tag{7}$$

---

2 The grid search procedure does not give the same results as a Maximum Likelihood estimation. However, the larger the number of observations the more the results will be the same (Maddala 1977, p. 279). For finite samples the Maximum likelihood approach well not yield exact results either. In fact, it has been shown in some limited Monte Carlo experiments (Anselin 1981) that ad hoc iterative procedures (à la Cochrane-Orcutt and Durbin) based on OLS estimation may perform acceptably or even superior in terms of bias and mean squared error.

4. Data and estimation

The data employed here consist of regional (domestic) product, labour, private capital differentiated into equipment capital and structures and public capital on the state level for the eleven West German federal states for the period 1970 to 1991. All data have been compiled by the Arbeitskreis Volkswirtschaftliche Gesamtrechnung of the statistical offices of the West German Länder.

The presentation of the results begins with the set of estimates for which it is assumed that there are no spillover effects. The panel data estimation that is presented in Table 1 takes account of time effects. There are no restrictions imposed on the estimated coefficients.

Table 1: Estimates of State Production Function
Dependent Variable: Log Gross Regional Product per Worker

Variable	OLS TOTAL	FIX	RANDOM
Ln Priv. Equ. Capital per Wkr	0.921185	0.937454	0.932487
	(0.018443)	(0.015919)	(0.015735)
Ln Priv. Struc. Capital per Wkr	0.091505	0.108834	0.108179
	(0.020366)	(0.017892)	(0.017686)
Ln Public Sector Capital	0.07248	0.014258	0.013994
	(0.00821164)	(0.009599)	(0.0090128)
Adjusted R-squared	0.999714	0.99852	0.99895
Sum of squared residuals	4.060709	2.78080	2.98345

The first column shows the results of the ordinary least squares estimation of equation (1) pooling the data of all eleven states. The coefficient for private equipment capital per head is very high , while those for private structures per head and public capital are very low. All the coefficients have positive sign and are statistically significant at conventional significance levels. However, the F-test on whether we can pool the time series using the residual sum of squares of the estimates on the time series of the individual states shows that interstate differences are significant even at the 1% significance level. Hence we should not simply pool the data.

The second column gives the results for the estimation assuming fixed effects for the individual states. That is, it is assumed that there are non-stochastic intercepts for each state. The coefficient for private capital per head is slightly increased compared to the OLS estimate on the entire sample and the coefficient for public capital is even further reduced. Moreover, the reduction of the public capital coefficient makes it statistically insignificant. As mentioned before a major objection against the conventional fixed effects approach is the use of deviations from state specific means which implies that the parameters are identified by relying on the annual variation over time within each state only.

The third column gives the results for a random effects estimator under the assumption that the intercepts are uncorrelated. Using this procedure the coefficient for public sector capital assumes an even lower value than with the fixed effects procedure. Also in this case it is statistically insignificant. The result that private capital investment per head is by far the most important argument for the state level productivity growth is confirmed. Both the coefficients on private equipment capital per head and private structures per head are statistically significant. We tested the null hypothesis that the state effects are uncorrelated with observed quantities of input variables by comparing the fixed -effects estimatior and the GLS estimator for the random effects (Hausmann and Taylor 1981). It turned out that we cannot reject that hypothesis and that hence correlation between right hand terms and the random state effects does not seem to be a problem.

To sum up the panal data estimates: Only using OLS estimation on the total data set we obtain a coefficient for public sector capital that is statistically insignificant. In the other cases we cannot reject the hypothesis that public sector capital is unimportant for the growth of labour productivity at the margin. The OLS estimation on the pooled data set is, however, discredited by the relatively high sum of squared residuals which implies the F-test result that the data should not be pooled.

In Table 2 we present the results obtained from the spatial Seemingly Unrelated Regression model. It refers to the years 1981 to 1991 only as in the decade 1971 to 1980 there has been very little regional variation in public capital growth (Seitz and Licht 1993, p 117). That is, we allow for random state specific effects and take account of interregional interdependence in the way explained above. This gives the following vector of time specific spatial autocorrelation coefficients:

$$\lambda = \begin{pmatrix} -0.52 \\ -0.54 \\ -0.54 \\ -0.59 \\ -0.55 \\ -0.50 \\ -0.57 \\ -0.57 \\ -0.59 \\ -0.57 \\ -0.55 \end{pmatrix}$$

That is, the coefficient has a relatively constant value and a negative sign for the whole decade. Compared to the panel data estimates the coefficient for private equipment capital per head remains clearly the most important one. Taking account of the spatial autocorrelation between neighbouring states considerably increases the value of the coefficient of private structures per head. It increases only slightly the low value of the public capital coefficient. However, it is significant even at the one percent significance level.

Table 2: Seemingly Unrelated Regression Results for the Sub-Period 1981-1991

Parameter	Estimate	Standard Error	t-statistic
β_1	0.784086	0.103203E-02	759.748
β_2	0.233589	0.652619E-03	357.926
β_3	0.017493	0.118308E-02	14.7859

The standard errors are computed from quadratic form of the analytic first derivatives.

The results suggest that public sector capital had a rather low influence on labour productivity. Statistical significance of a positive coefficient is established when using the spatial Seemingly Unrelated Regression model. That is taking account of spatial interdependence, i. e. allowing for the existence of spillover effects of the regional growth processes enhances the possibility of getting a positive, significant coefficient albeit of low magnitude.

6. Conclusions

In this paper we show that using a production function approach in intensive form and statistical data from the regional account statistics of the West German federal states we cannot confirm the hypothesis that public sector capital plays a major role for labour productivity growth. Rather, we obtain the result the level of private equipment capital per head is the by far most important variable to explain growth in labour productivity. We have shown that to take account of the spillovers of the regional growth processes, i. e. of spatial autocorrelation between neighbouring states results in an improvement of the parameter estimates. The coefficient for public sector capital is positive but has a very low numerical value. That is, from the results of the panel estimates and the econometrically superior spatial seemingly unrelated regression model we cannot infer that public capital has been important for labour productivity growth at the margin. In this sense the experience of the West German federal states does not allow the conclusion that public sector capital accumulation automatically and decisively leads to growth in the East German Länder.

APPENDIX A:

Data sources

All data used in the econometric analysis stem from regional accounts of the German federal states[3]. The regional accounts are prepared by the respective Federal State's statistical offices and published by a common working committee.

The productivity variable is defined as the regional gross domestic product per worker. Private and public capital stock consist of yearly purchases of durable, reproducible capital goods. The variables are net of depreciation in constant prices of 1991 and aggregated according to the permanent inventory method. They exclude military equipment and structures as well as durable goods used by private households. Capital goods are those durable producer goods which have life cycle of more than one year

'Equipment' comprises machinery, vehicles and the equipment of firms that can be used independently of the structures. 'Structures' include buildings, roads, bridges, tunnels, airports etc. Equipment that is part of the structures (lifts, heating systems etc.) is counted as belonging to the structures. Public underground structures are not part of the public capital.

---

3 Cf. Gemeinschaftsveröffentlichung der Statistischen Ländesämter, Vokswirtschaftliche Gesamtrechnungen der Länder. Heft 23 Stuttgart 1994, and

Gemeinschaftsveröffentlichung der Statistischen Landesämter, Vokswirtschaftliche Gesamtrechnungen der Länder. Heft 17: Anlagevermögen, Anlageinvestitionen und Abschreibungen der Länder der Bundesrepublik Deutschaland 1970 bis 1986. Stuttgart 1987.

For the provision of unpublished data on real private and public capital of the individual federal states we would like to thank Mr. Zander of the Statistisches Landesamt Schleswig-Holstein.

APPENDIX B: Estimation results obtained from the cross sections of individual years

Equation EQ81
****

Dependent variable: Y12

Mean of dependent variable = 25.2299
Std. dev. of dependent var. = 7.82891
Sum of squared residuals = 0.102617
Variance of residuals = 0.932882E-02
Std. error of regression = 0.096586
R-squared = 0.999889
Durbin-Watson statistic = 1.87364

Equation EQ82
****

Dependent variable: Y13

Mean of dependent variable = 26.3948
Std. dev. of dependent var. = 8.48339
Sum of squared residuals = 0.207920
Variance of residuals = 0.018902
Std. error of regression = 0.137484
R-squared = 0.999906
Durbin-Watson statistic = 1.10062

Equation EQ83
****

Dependent variable: Y14

Mean of dependent variable = 27.0535
Std. dev. of dependent var. = 8.83102
Sum of squared residuals = 0.203356
Variance of residuals = 0.018487
Std. error of regression = 0.135967
R-squared = 0.999893
Durbin-Watson statistic = 1.41348

Equation EQ84
****

Dependent variable: Y15

Mean of dependent variable = 27.1187 Std. error of regression = 0.125580
Std. dev. of dependent var. = 8.84700 R-squared = 0.999872
Sum of squared residuals = 0.173473 Durbin-Watson statistic = 1.82171
Variance of residuals = 0.015770

Equation EQ85
****

Dependent variable: Y16

Mean of dependent variable = 28.6014 Std. error of regression = 0.116938
Std. dev. of dependent var. = 9.67644 R-squared = 0.999895
Sum of squared residuals = 0.150418 Durbin-Watson statistic = 2.00592
Variance of residuals = 0.013674

Equation EQ86
****

Dependent variable: Y17

Mean of dependent variable = 27.4572 Std. error of regression = 0.111582
Std. dev. of dependent var. = 9.02313 R-squared = 0.999876
Sum of squared residuals = 0.136955 Durbin-Watson statistic = 2.21089
Variance of residuals = 0.012450

Equation EQ87
****

Dependent variable: Y18

Mean of dependent variable = 28.0458 Std. error of regression = 0.108615
Std. dev. of dependent var. = 9.35872 R-squared = 0.999896
Sum of squared residuals = 0.129771 Durbin-Watson statistic = 2.13948
Variance of residuals = 0.011797

Equation EQ88
****

Dependent variable: Y19

Mean of dependent variable = 28.1098 Std. error of regression = 0.096470
Std. dev. of dependent var. = 9.38498 R-squared = 0.999915
Sum of squared residuals = 0.102371 Durbin-Watson statistic = 2.22609
Variance of residuals = 0.930646E-02

Equation EQ89
****

Dependent variable: Y20

Mean of dependent variable = 28.7401 Std. error of regression = 0.104862
Std. dev. of dependent var. = 9.73332 R-squared = 0.999922
Sum of squared residuals = 0.120956 Durbin-Watson statistic = 1.87978
Variance of residuals = 0.010996

Equation EQ90
****

Dependent variable: Y21

Mean of dependent variable = 28.2133	Std. error of regression = 0.145122
Std. dev. of dependent var. = 9.42957	R-squared = 0.999903
Sum of squared residuals = 0.231665	Durbin-Watson statistic = 1.03940
Variance of residuals = 0.021060	

Equation EQ91
****

Dependent variable: Y22

Mean of dependent variable = 27.6770	Std. error of regression = 0.235738
Std. dev. of dependent var. = 9.12120	R-squared = 0.999882
Sum of squared residuals = 0.611296	Durbin-Watson statistic = 0.402732
Variance of residuals = 0.055572	

References

Anselin, Luc
Spatial Econometrics. Methods and Models. Dordrecht 1988.
Anselin, Luc
Small sample properties of estimators for the linear model with a spatial autoregressive structure in the disturbances. In: Modelling and Simulation, vol. 12, 1981, pp. 899-904.
Arbeitsgemeinschaft Volkswirtschaftliche Gesamtrechnung der Statistischen Landesämter
Gemeinschaftsveröffentlichung der Statistischen Ländesämter, Vokswirtschaftliche Gesamtrechnungen der Länder. Heft 23 Stuttgart 1994, and
Arbeitsgemeinschaft Volkswirtschaftliche Gesamtrechnung der Statistischen Landesämter
Gemeinschaftsveröffentlichung der Statistischen Landesämter, Vokswirtschaftliche Gesamtrechnungen der Länder. Heft 17: Anlagevermögen, Anlageinvestitionen und Abschreibungen der Länder der Bundesrepublik Deutschland 1970 bis 1986. Stuttgart 1987.
Aschauer, David
Is public expenditure productive? In: Journal of Monetary Economics, vol. 23 (1989a), pp. 177-200.
Aschauer, David
Public investment and productivity growth in the Group of Seven. In: Economic Perspectives, vol. 13 (1989b), pp. 17-25.
Barro, R.
Government spending in a simple model of endogenous growth. In: Journal of Political Economy, Vol. 98 (1990), pp. S103-S125.
Barro, R.
Public Finance in models of economic growth. In: Review of Economic Studies, Vol. 59 (1992), pp. 645-661.
Berndt, E. R. and B. Hansson
Measuring the contribution of public infrastructure capital in Sweden. In: Scandinavian Journal of Economics, vol. 94 (1992), supplement, pp. 151-168.
Bradford de Long, J. and L. H. Summers
Equipment investment and economic growth: how strong is the nexus? In: Brookings Papers on Economic Activity, 1992, no. 2, pp. 157-199.
Bundesministerium für Wirtschaft
Strategie für den Standort Deutschland: Wirtschaftspolitik für die neunziger Jahre. BMWI Dokumentation Nr. 327. Bonn 1992.
Deutsches Institut für Wirtschaftsforschung
Ein öffentliches Infrastrukturprogramm für Ostdeutschland. Berlin 1991.
Deutsches Institut für Wirtschaftsforschung
Wechselwirkungen zwischen Infrastrukturausstattung, strukturellem Wandel und Wirtschaftswachstum. Berlin 1994.

Ford, R. and P. Poret
Infrastructure and private sector productivity. In: OECD Economic Studies, No. 17, Autumn 1991, pp. 63-89.
Hakfoort, J.
Public capital productivity and economic growth: A macroeconomic perspective. In: Tinbergen Research Institute Research Bulletin, Vol. 5, 1993, pp. 205-214.
Hildreth, C. and J. Y. Lu
Demand relations with autocorrelated disturbances. AES Technical Bulletin 276. Michigan State University. East Lansing, Mich. November 1960.
Holtz-Eakin, Douglas
Public-sector capital and the productivity puzzle. In: The Review of Economics and Statistics, Vol. 125 (1994), pp. 12-21.
Hulten, Ch. and R. Schwab
Regional productivity growth in U.S. manufacturing 1951-1978.. In: American Economic Review, vol. 74 (1984)), pp. 152-162.
Jones, Larry E. and Rodolfo Manuelli
A convex model of equilibrium growth. In: Journal of Political Economy, vol. 98 (1990), pp. 1008-1038.
Jones, L. E.; R. E. Manuelli, and P. E. Rossi
Optimal taxation in models of endogenous growth. In: Journal of Political Economy, Vol. 101 (1993), pp. 485-517.
King, Robert G. and Sergio Rebelo
Public policy and economic growth: Developing neoclassical implications. In: Journal of Political Economy, vol. 98 (1990), pp. S126-150.
Lynde, C.
Private profit and public capital. In: Journal of Macroeconomics, vol. 14 (1992), pp. 125-149.
Maddala, G. S.
Econometrics. New York 1977.
McDonald, D. and G. Thumann
Investment needs in East Germany. In: L. Lipschitz and d. McDonald (Eds.): German Unification, Economic Issues. International Monetary Fund. Washington 1990.
Munnel, Alicia
How does public infrastructure affect regional economic performance. In: A. Munnell (ed.): Is There a Shortfall in Public Capital Investment?. Boston 1990b.
Munnell, Alicia
Why has productivity growth declined? In: New England Economic Review, 1990a, pp. 3-22.
Rebelo, Sergio
Long-run policy analysis and long-run growth. In: Journal of Political Economy, vol. 90 (1991), pp. 500-521.
Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung
Auf dem Wege zur wirtschaftlichen Einheit Deutschlands. Jahresgutachten 1990/91. Stuttgart 1990.

Schrumpf, H.
Engpässe in der Infrastruktur in den neuen Bundesländern. In: Die deutsch-deutsche Integratio, Beihefte der Konjunkturpolitik, Heft 39 (1992), pp. 127-140.
Seitz, H.
Public capital and the demand for private inputs. In: Journal of Public Economics, vol. 54 (1994), pp. 287-308.
Seitz, H. and G. Licht
Public infrastructures, manufacturing production cost, and the demand for private inputs: a regional analysis. In: Gesellschaft für Regionalforschung, Seminarbericht 33 (1993), pp. 114-132.
Tanzi, V.
The IMF and Tax Reform. Fiscal Affairs Department IMF Working Paper 1990.
Vesper, Dieter
Grundlagen, Ergebnisse und Aussagekraft von Schätzungen des öffentlichen Finanzierungsbedarfs. In: Friedrich Ebert Stiftung (Hrsg.): Finanzierung der Deutschen Einheit. Grundlagen und Perspektiven. Bonn 1993.