Regional Economic Interaction and the Role of Growth Poles in East Germany's Convergence Process

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Abstract

What is the effect of location and spatial proximity on regional productivity growth and convergence? Applying the toolbox of 'spatial econometrics' to a cross section of East and West German regions the extent and geographical scope of spillovers among regions is investigated, distinguishing between three different forms of interaction, namely local growth, shock, or convergence clusters. It is shown that spatial proximity has mattered for both East and West German regions in the 1990s. The driving forces, however, are different. In East Germany local convergence clusters have dominated: Regions with comparatively rich neighbors have grown faster than regions with poor neighbors. By contrast, in West Germany, like in other mature industrialized countries in Europe an the U.S., interaction among neighboring regions has been driven by the transmission of unanticipated shocks. The main reason, it is argued, is that forward and backward linkages among firms which used to be important channels of shock transmission are still underdeveloped in East Germany.

Within this system of economic interdependencies across space, the presumed East German growth poles do not play an outstanding role. There is no evidence for them having fostered economic growth in their neighborhood to a larger extent than other regions. As a consequence, concentration of regional development aid on those growth poles, as has gained prominence in public discussion recently, might not yield the desired benefits to a larger number of surrounding regions.

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1. Introduction

Following German unification in 1990 East Germany has experienced a rapid transformation of its economy and a fast convergence vis-à-vis West German income and productivity levels. In the first half of the 1990s per-capita income, measured as gross value added per inhabitant, went up from 50 per cent of the West German level in 1990 to about 68 per cent in 1996; labor productivity (gross value added per worker) went up to about 72 per cent, from 57 per cent in 1990.

In the second half of the decade, however, economic convergence between East and West Germany came to a halt; the east was not able to continue its rapid catch-up process. Most analyst assume this break in the convergence process to be temporary. One reason is the structural crisis in construction industries since the mid-1990s which has slowed down the speed of convergence between East and West Germany.[1] Another reason is perceived to be the lack of local networks. After a phase of rapid expansion of the industrial base which was driven mainly by transforming huge and inefficient state-owned industrial holdings into modern production facilities, and by establishing new firms, the pace of new firm formation has slowed down considerably since the mid-1990. Consequently, the growth of existing firms, and the exploitation of potentials for enhancing productivity by deepening the division of labor, and by taking advantage of economies of localization, e.g. by networking, have gained importance as driving forces of growth. The formation of networks and clusters, however, is still in its initial phase (Ragnitz et al. 2001, Kehrer 2000). To date there are only a few clusters of related economic activities in East Germany.[2]

Public policy has extensively supported the transformation and catch-up of the East German economy by a variety of measures. Up to now these measures have been granted to all East German regions alike, which may be one reason for the fact that regional productivity and income inequalities within East Germany have narrowed substantially, and are much lower than in West Germany today.[3]

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[1] Conversely, the construction boom in the early 1990s sped up convergence until the mid 1990s. Huge amounts of public and private capital were invested in modernizing and expanding the physical infrastructure, production plants, and housing. For details see DIW et al. (2002).

[2] One example is the electronics cluster around Dresden, another the optics cluster in Jena around Jenoptic, and a third the automobile clusters in Chemnitz and Eisenach. See DIW et al. (2002), and Blien, Wolf (2002), among others.

[3] During the 1990s, regional productivity levels within East Germany showed a rapid convergence. The coefficient of variation across the 112 counties (including West Berlin) dropped from 13.2 per cent in 1992 to 8.0 per cent in 2000 while that across the 327 West German counties rose from 13.1 to 14.1 per cent. Per-capita income levels converged as well, albeit less rapidly (from 26.5 in 1992 to 25.3 in 2000), while West Germany experienced a significant divergence in regional per-capita income, starting at a much higher level of inequality (37.6 to 41.0 per cent). See DIW et al. (2002) for more details.

With a view to the lack of convergence towards West Germany since the mid-1990s, and to the comparatively low regional income inequalities within East Germany some scholars, among which is the influential German Council of Economic Advisors[4], argue that public regional assistance should be concentrated onto growth poles (Council 1999: 133) rather than benefiting all regions to the same extent. It would be more efficient, they argue, to build upon, and activate the existing growth potentials of a few agglomerations rather than creating new ones in more peripheral regions. According to the concept of growth poles which goes back to Perroux (1955) and Boudeville (1966) the latter are expected to benefit indirectly, namely from geographic spillovers of growth impulses originating from the fast-growing poles.[5]

The aim of the present empirical investigation is twofold: First, we will present empirical evidence on the question how, and to what extent neighboring regions in East Germany are interdependent in the process of economic convergence. Does a region benefit (or suffer) economically from being located in close proximity to prosperous, or rich regions? And second, the paper aims at contributing to the political debate on whether or not regional assistance should be concentrated onto growth poles by assessing empirically to what extent the perceived poles really have played a prominent role in producing positive spatial externalities to the benefit of regions in their geographic neighborhood.

In the literature the question as to whether, and to what extent neighboring regions affect each other economically has been addressed in several ways: One has been to explore the extent and intensity of cooperation and networking between firms. This kind of analysis usually is restricted to a rather limited geographical area because it requires a detailed analysis at the microeconomic level, with necessary information often being gained from case studies. Examples are studies of industrial clusters, innovative milieux, and so on.[6] Another way has been to explore the aggregate pattern of spatial dependence as it shows up in a correlation between appropriate macroeconomic indicators from different regions. Within the latter approach which is preferred here, the spatial econometrics toolbox provides a particularly useful methodology because it explicitly takes into account the two-dimensional structure of the data.[7]

A considerable number of empirical investigations have addressed the role of economic dependencies between regions in general. They indicate that regions cannot be assumed to be

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[4] ‘Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung’ in German. In what follows we will quote it as ‘Council’ for simplicity.

[5] See Richardson (1979: 164 ff.) for a very useful – and critical – description of the concept of growth poles.

[6] See Enright (2001) for an excellent review.

[7] Another approach is spatial Markov chains as proposed by Rey (2001). See also Bickenbach, Bode (2001) for a number of statistical tests on the relevance of neighborhood effects.

closed economies: There is convincing evidence for strong correlation of income and productivity growth rates, innovative activities, and various labor market indicators, among others, across regions in various countries like the U.S., or the European Union (as a whole as well as in single Member States).[8] Most interestingly in this context, Rey and Montouri (1999) find that a random growth shock to the state of Missouri in the center of the USA will be propagated through large parts of the country because of spatial dependence: Income growth in one state is not independent of what happens to its neighbors. Similar effects have been reported by Baumont et al. (2000) for European regions. By contrast, we are not aware of a recent contribution to the literature focusing on spatial spillovers originating from growth poles.

The present paper is divided into two major parts. As a first step the form and extent of economic interaction between all East German regions and their respective neighbors[9] will be identified (section 2). As a second step the specific role of potential growth poles will be assessed by testing whether or not spatial spillovers originating from these poles exceed those originating from other, non growth-pole regions (section 3). That is: The central question is 'Do spatial spillovers from growth poles exceed those from other regions' rather than just 'Are there spatial spillovers from growth poles'. Although the focus of the analysis in on East Germany the analysis will be done for West Germany as well for comparison.

2. Regional interdependencies

1. Conceptual framework and methodology

Neighborhood effects may be identified within an empirical model of income convergence, as developed by Sala-i-Martin (see, e.g. Barro, Sala-i-Martin 1991) from a neoclassical (Solowian) model of exogenous growth.[10] Assuming preferences and technologies and, thus, steady state income growth to be the same in all regions within an economy the approach simply holds that regions which are actually poor in terms of per-capita income and/or labor productivity levels should grow faster than richer ones in their adjustment process towards equilibrium:[11]

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[8] See, among many others, Rey, Montouri (1999), Anselin et al. (2000), Rey (2001a, 2001b), and Bickenbach, Bode (2001) for regions in the U.S.; Fingleton and McCombie (1998), Fingleton (1999), Baumont et al. (2000), Bottazzi, Peri (2000), and Greunz (2002) for EU regions; or Büttner (1999), Niebuhr (1999), and Bode (2001, 2002), for West German regions.

[9] A more detailed definition of 'neighborhood' will be given below.

[10] For similar approaches see Rey, Montouri (1999) and Baumont et al. (2000).

[11] One reason suggested by neoclassical growth theory is decreasing marginal productivity of capital; there may, however, be other reasons for the same mechanics derived from other growth models. For example, regional convergence can be derived as well from a leader-follower model of endogenous growth where an economically and technologically lagging region successfully adopts (imitates) innovations developed in the technologically leading regions at costs which are far below the innovation costs (see, e.g. Barro, Sala-i-

$$\hat{y}_r = \tfrac{1}{T}\left(\ln y_{rt+T} - \ln y_{rt}\right) = \beta_0 + \beta_1 \ln y_{rt} + u_{rt}\,, \qquad (1)$$

or $\hat{y} = X\beta + u$ in matrix notation. y_{rt} denotes per-capita income or labor productivity in region r ($r = 1, \ldots, R$) at time t, T the number of periods under consideration, β_0 a constant term reflecting, i.a., characteristics of the steady state equilibrium and the rate of (exogenous) technical progress which is assumed to be the same across all regions, β_1 the convergence parameter, and u_{rt} a random error term. The model (1) is formally equivalent to a model of partial adjustment (towards the steady state growth path): $\beta_1 < 0$ indicates convergence; $\beta_1 > 0$ indicates divergence; $\beta_1 = 0$ is similar to a random walk in time-series analysis.

The basic convergence regression approach (1) can be extended to capture three different forms of neighborhood effects between regions alternatively:

1. Local growth clusters: Neighboring regions may form growth clusters such that they evolve along similar growth paths which are different from the growth paths of other regions – independent of the individual income levels of the regions involved. Such growth clusters may result from the fact that neighboring regions which share the same factors of location and comparative advantages specialize on the same technologies. Another reason may be a close interdependence of economic activity, e.g. through extensive forward and backward linkages. Formally a growth cluster can be characterized as follows: A regions expected growth rate of income and/or productivity depends systematically on the growth rates realized by its neighboring regions. In spatial econometrics this is the typical case of a spatially lagged dependent variable;[12] a convergence regression approach capturing regional growth clusters reads[13]

$$\hat{y}_r = \beta_0 + \beta_1 \ln y_r + \rho \sum_{\substack{s \in R_r \\ s \neq r}} w_{rs} \hat{y}_s + u_r\,, \qquad \sum_{\substack{s \in R_r \\ s \neq r}} w_{rs} = 1\,, \qquad (2)$$

resp. $\hat{y} = X\beta + \rho W\hat{y} + u$

in matrix notation. The additional variable $\Sigma w\hat{y}$, resp. $W\hat{y}$, is the weighted average of growth rates across those R_r regions that are defined as being neighbors to r; the weights w_s determine

Martin 1995: 266 ff.). Therefore, the convergence approach sketched above cannot discriminate between different growth theories.

12 For details see Anselin (1988). The term "spatial lag" indicates certain similarities to a time lag in time-series analysis, the only differences being that in a cross section the variable is lagged in the geographical rather than in the time dimension, and that dependence across space is assumed to be mutual (i.e., from *r* to *s and vice versa*) rather than unidirectional (from *t*-1 to *t but not from t to t-1*), as is usually assumed in time-series analysis. We will return to the methodological problems introduced by the *inter*dependence later.

13 The time index is suppressed for simplicity.

the relative strength of growth impulses on *r* originating from region *s*.[14] Consequently, W is a predetermined spatial weights matrix of dimension (RxR) which defines neighborhood, and the relative strength of interregional spillovers: In the *r*-th row of W corresponding to the *r*-th observation in the sample there are non-zero entries only in those columns corresponding to neighbors to *r*. All other cells (including that on the main diagonal) have entries zero. The row-sums in W are standardized to unity.

A positive parameter ρ in (2) indicates that regions benefit from prosperous neighbors but suffer from neighbors that perform poorly in terms of economic growth, while a negative parameter indicates adverse spillovers of growth impulses.

For simplicity the presentation in this paper focuses on the case of interdependencies between regions. It should be noted, however, that – taken literally – the present analysis cannot discriminate unequivocally between true interdependencies between regions in the sense of economic growth in one region depending directly on what happens in a neighboring region, and mere co-movements of growth rates resulting from external influences (like global technological change, changes in relative prices) which affect neighboring regions in the same way but independent of each other. Nonetheless, we believe this kind of analysis to be helpful because it allows for identifying spatial regularities in economic development and convergence, and because it gives us an idea as to where to look for the driving forces of these regularities.

2. Local shock clusters: Alternatively neighboring regions may form a shock cluster such that a local shock which initially strikes one region transmits to neighboring regions to a significant extent[15] – both independent of any differences in income levels or income-growth rates between the regions involved.[16] Formally a shock cluster can be characterized as follows: A regions expected growth rate of income and/or productivity depends systematically on the unexpected growth (realized minus expected) in its neighboring regions. In spatial econometrics this is the typical case of a spatial error model, i.e., a model where the residuals exhibit

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[14] The weighting schemes most frequently used in empirical analysis are first-order neighborhood (all regions sharing a border with *r* are given the same weight), or inverse distances between economic centers of the regions; the latter reflecting the idea of a gravity approach according to which the strength of economic interaction between any two locations should diminish with increasing geographical distance.

[15] Alternatively, a local shock cluster may comprise neighboring regions being affected by global economic shocks in a similar way but independent of each other.

[16] The channels through which shocks are transmitted over space may be the same as those for growth impulses, namely close forward and backward linkages between regions. The question of whether growth or shock clusters dominate, thus, may be merely one of periodicity: While in the long term growth impulses can be expected to dominate comparative regional development, shocks may be more important in the short run. Nonetheless, it is possible to discriminate statistically between both types of spatial dependence, as will be shown below.

spatial autocorrelation. This can be modeled by assuming the error term u in (1) to follow an autoregressive process such as

$$u_r = \lambda \sum_{\substack{s \in R_r \\ s \neq r}} w_{rs} u_s + \varepsilon_r , \qquad \text{resp. } u = \lambda \mathrm{W} u + \varepsilon \; ; \qquad \sum_{\substack{s \in R_r \\ s \neq r}} w_{rs} = 1 , \; \varepsilon \text{~i.i.d.} \tag{3}$$

Substituting (3) into (1) yields the spatial error model

$$\begin{aligned} \hat{y} &= \mathrm{X}\beta + \lambda \mathrm{W}(\hat{y} - \mathrm{X}\beta) + \varepsilon \\ &= \mathrm{X}\beta + \lambda \mathrm{W}\hat{y} - \gamma \mathrm{WX} + \varepsilon \end{aligned} \tag{4}$$

A positive (negative) autocorrelation parameter λ in (4) indicates that a positive (adverse) growth shock arriving in one or more neighbors of region r affects economic growth in r positively (negatively) as well. One necessary condition, however, is that the restriction

$$\gamma = \lambda \beta \tag{5}$$

which is labeled ‘common-factor hypothesis’ is satisfied. $\gamma \neq \lambda\beta$, by contrast, indicates that the shock cluster model is not valid (Anselin 1988: 226 ff.). In this case the growth cluster model is preferred provided ρ in (2) is significantly different from zero.

3. Local convergence clusters: Finally, neighboring regions may form a convergence cluster such that a region’s income growth is affected by the income levels attained in neighboring regions – independent of its own income level, and of the speed of income growth realized by the neighbors. Formally a local convergence cluster can be characterized as follows: A regions expected growth rate of income and/or productivity depends systematically on the absolute income level in its neighborhood. In the present context this is the typical case of a spatially lagged exogenous variable. The appropriate model reads

$$\hat{y} = \mathrm{X}\beta + \mathrm{WX}\delta + u \tag{6}$$

where WX is the weighted average income level in neighboring regions. A positive convergence parameter δ indicates that a region benefits from rich neighbors in terms of income growth but suffers from poor ones – in addition to those growth impulses that result from the general tendency towards convergence, and that are reflected by a negative convergence parameter β_1.

The empirical investigation is based on productivity figures (gross value added per worker)[17] for a cross section of 112 East German counties (Landkreise) including West Berlin, resp. 327

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[17] An alternative indicator which has been employed frequently in the convergence literature, namely per-capita income (e.g. gross value added per inhabitant), is less useful in the present context because it is biased by commuting across county borders. The nominator (gross value added) refers to the workplace, the

West German counties.[18] It should be noted that the convergence regression approach (1) is subject to a number of methodological shortcomings (see Durlauf, Quah 1999). Most notably, the convergence parameter (β_1) may be biased downward (i.e. towards convergence) due to "Galton's fallacy",[19] especially in cases where the observations for the start and the end of the time period under consideration (t and $t+T$) are taken from single years. Although the convergence parameter is not of primary interest in the present paper we make an attempt to reduce the bias by using two-years' averages (1992/94 and 1998/2000) as starting and ending points. Consequently, the time period under consideration is assumed to comprise approximately T=6 years (1993-99).

As noted earlier the spatial weights matrix W must be assumed to be exogenous and given in models with spatially lagged variables. In practice, however, the spatial scope of the clusters discussed above is a priori unknown. Therefore we test two different weighting schemes alternatively. First, we define a binary first-order contiguity matrix W_N where significant neighborhood effects are assumed to be effective only between regions sharing a common border. All neighbors are given the same weight which, following the notation used above, is equal to $1/R_r$ in the row-standardized matrix;[20] all other regions are assigned the weight 0. Second, we adopt the idea of a gravity approach by assuming that the intensity of spillovers decreases with increasing distance between any two regions. The (r,s) element of the resulting spatial weights matrix W_D is

$$w_{Drs} = D_{rs} \Big/ \sum_{\substack{s=1 \\ s \neq r}}^{R} D_{rs} \,, \qquad \sum_{s=1}^{R} w_{Drs} = 1,$$

where D_{rs} denotes the distance between regions r and s. As distance measures we use great circle distances between the economic centers of the counties.[21]

The spatial weights matrices are used not only for defining spatially lagged explanatory variables but also for tests of spatial dependence which is not captured by the respective model. In

denominator (population) to the place of residence. Consequently, the parameters of spatially lagged variables are hardly reliable. The labor productivity indicator, by contrast, is unbiased because both nominator and denominator refer to the workplace.

18 We prefer a cross-section rather than a panel data approach since there are only five observations available in the time-series dimension (1992–2000), with figures for 2000 being estimated. Regional accounts statistics for German counties are available for every second year only. Data is from Statistisches Landesamt Baden-Württemberg (2001).

19 For details see Friedman (1992), Quah (1993), or DiNardo, Tobias (2001: 19 f.).

20 In the present context where all variables are in relative terms rather than absolute levels it makes no sense to use not row-standardized weights matrices because this would result in adding up growth rates, or ratios which are non-additive.

21 The coordinates of the economic centers are from the 'Bundesanstalt für Bauwesen und Raumordnung' Bonn.

total five different tests are performed: General spatial dependence is tested for by a Moran's I test; residual spatial autocorrelation is tested for by two Lagrange Multiplier tests (LM_{ERR}, robust LM_{ERR}[22]); and spatial lag dependence is tested for by LM_{LAG} and robust LM_{LAG} tests.[23] With each test being applied to two different spatial weight concepts a total of 10 test statistics are calculated for each regression to detect unexplained spatial dependence. The power of these tests depends on several aspects, including the complexity of the spatial weights matrix, and the sign and the strength of dependence (Anselin and Rey 1991; Anselin and Florax 1995). This is particular relevant for the spatial weights matrix featuring inverse distances. To improve the power of these tests we introduce a maximum distance of 60 km which may be perceived as some sort of a threshold for frequent face-to-face contacts.[24] That is, the influence of regions whose economic centers are more than 60 km off those of region *r* is a priori restricted to zero.[25]

2. Empirical results for East Germany

Table 1 reports the results for the basic convergence model without spatial effects (equation 1), and the three models for different forms of spatial interdependencies (equations 2, 4, and 6).[26] The basic model explains 43 per cent of the total variation in the sample which is not too bad for a cross-section regression. But the two LM test statistics for spatial lag dependence and spatial autocorrelation which are highly significant[27] indicate that there is some spatial regularity in the data which is not explained by the basic convergence model. Consequently, the model is inefficient.

In search for the appropriate specification for the unexplained spatial dependence we first test the local growth cluster approach (eq. 2) by adding a spatially lagged endogenous variable to the basic convergence model (column 2 of Table 1). Since OLS produces inconsistent estimates the model has to be estimated using a Maximum Likelihood (ML) approach that takes into consideration the interdependence between neighboring regions.[28]

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22 "Robust" means robust against the respective other form of spatial dependence.

23 For methodological details see Anselin (1988); (1995); Anselin et al. (1996).

24 The idea is that extensive interaction among agents usually requires frequent face-to-face contacts. The higher the distance between the agents involved the higher are the transaction costs of meetings.

25 The regression have been done using software packages SAS, and SpaceStat.

26 One outlier, Hoyerswerda, has to be neutralized by a dummy because its extremely poor economic performance cannot be explained by the convergence model to a sufficient extent.

27 The tests indicate substantial and highly significant spatial dependence for both concepts of neighborhood, defined by first-order contiguity, and by inverse distances. The respective statistics for the latter which are not reported in Table 1 are LM_{ERR}=5.19 (prob=0.03) and LM_{LAG}=4.27 (0.04).

28 In contrast to time-series analysis with a serially lagged dependent variable OLS estimates are biased and inconsistent even if the residuals are not autocorrelated because $\text{plim} R^{-1}(\hat{y}'W'u) \neq 0$ can be shown to be

Table 1 — Spatial dependence among East German counties 1992/94 – 1998/2000[a]

	basic model		growth cluster		shock cluster		convergence cluster	
	(1) OLS		(2) ML		(3) ML		(4) OLS	
	parameter	prob[b]	parameter	prob[b]	parameter	prob[b]	parameter	prob[b]
Constant	0.914	0.00	0.914	0.00	0.949	0.00	0.655	0.00
productivity 1993	-0.080	0.00	-0.079	0.00	-0.083	0.00	-0.081	0.00
growth neighbors[c]	—		-0.097	0.36	—		—	
residuals neighbors[c]	—		—		0.096	0.45	—	
productiv. neighbors[c]	—		—		—		0.025	0.02
dummy Hoyerswerda	-0.030	0.01	-0.027	0.01	-0.026	0.01	-0.028	0.00
Moran's I[e. i]	0.06(D)	0.19	.		.		0.03(D)	0.38
LM_{ERR}[f. i]	7.24(N)	0.01	9.10(N)	0.00	.		1.97(N)	0.16
LM_{LAG}[g. i]	7.59(N)	0.01	.		7.98(N)	0.00	1.89(N)	0.17
LR-test: significance of spatial dependence[h]	—		0.97	0.33	0.63	0.43	5.60	0.02
no of regions	112		112		112		112	
R^2(adj.)	0.43		.		.		0.45	
log-Likelihood	362.7		363.1		363		365.5	
AIC[d]	-719.3		-718.3		-719.9		-723.0	

[a] Cross-section regressions for 112 East German counties; dependent variable: average annual productivity growth rate 1992/94 – 1998/2000. – [b] Error probability. – [c] Direct neighbors (with a common border). – [d] Akaike information criterion. – [e] Moran's I test for spatial dependence. – [f] Lagrange Multiplier test for spatial autocorrelation. – [g] Lagrange Multiplier test for spatial lag dependence. – [h] Likelihood-Ratio test for respective kind of spatial dependence (vis-a-vis the basic model (1). – [i] Table reports only test with lowest error probability; alternative spatial weights: N: direct neighbors (first-order binary contiguity), D: inverse distances up to 60 km.

However, the average rate of productivity growth in neighboring regions (common border)[29] neither succeeds in explaining the spatial dependence detected in the basic convergence model nor does it improve the explanatory power of the empirical model: The parameter of the lagged dependent variable ('growth neighbors') is not significantly different from zero (prob=0.36), a Likelihood Ratio test comparing the growth cluster to the basic model in column (1) does not indicate significant improvement of explanatory power (prob=0.33), the Akaike Information Criterion (AIC) takes a higher value (i.e., model is less preferable), and the LM_{ERR} tests still report highly significant spatial autocorrelation. Thus, the local growth cluster approach is not appropriate for describing economic interaction between regions in East Germany.

quadratic in the error terms. Consistent estimation requires either a Maximum Likelihood, or an Instrument variable estimation. For details see Anselin (1988: 58 ff.).

29 First-order contiguity is preferred over inverse distances as spatial weights for the lagged dependent variable because it produced the lowest error probability of the LM_{LAG} test in the basic model.

Second, when testing the local growth shock approach defined in eq. (4) we arrive at a similar conclusion (column 3):[30] The autocorrelation parameter (λ) reflecting spillovers of unexpected (resp. unexplained) productivity growth from a region's direct neighbors is not significantly different from zero, the AIC, and the LR test do not indicate a significant improvement of explanatory power vis-à-vis the basic convergence model, and the LM_{LAG} tests still indicate significant spatial dependence. Consequently, the local growth shock approach has to be rejected for East Germany as well.

Finally, the results for the local convergence approach (eq. 6) are reported in column (4) of Table 1. And what can be observed is that the average productivity level in neighboring regions seems to affect regional growth, indeed. The parameter δ is significantly positive, and the LR test as well as the AIC indicate that the explanatory power of the local convergence model is significantly higher than that of the basic model. Since, moreover, the Moran's I and LM tests do not indicate significant spatial dependence any more, we may conclude that the local convergence approach is, indeed, able to capture spatial interdependencies between East German regions appropriately. Obviously, regions with (on average) rich neighbors do grow faster than those with poor neighbors.

The point estimate for the parameter of spatially lagged productivity ($\hat{\delta}$ =0.025) suggests that a region whose neighbors are (on average) 10 per cent richer than those of another region is expected to grow 0.25 percentage points faster per annum (e.g. 4.25 vs. 4 per cent). This is not too much. But it may speed up convergence considerably. Take, for example, a region whose productivity level is 10 per cent below the East German average, and also 10 per cent below its neighbors' productivities. According to the point estimate of the convergence parameter ($\hat{\beta}_1$ =–0.081) this region is expected to grow 0.81 percentage points p.a. faster than a region with average productivity because of the economic forces driving regional convergence. Neighborhood effects contribute an additional quarter of a percentage point. That is, this region is expected to grow more than one percentage point faster than an average East German region with average neighbors.

3. Empirical results for West Germany

Applying the same procedure to a cross-section of 327 West German counties reveals quite some differences between the two parts of the country (Table 2). First of all, the convergence

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30 Again, a Maximum Likelihood approach is required because OLS estimates can be shown to be inconsistent because of the multidirectional nature of the spatial dependence (Anselin 1988: 59 ff.). And, again, first-order contiguity is preferred over inverse distances as spatial weights for the lagged dependent variable because it produced the lowest error probability of the LM_{ERR} test in the basic model.

Table 2 — Spatial dependence among West German counties 1992/94 – 1998/2000[a]

	basic model		growth cluster		shock cluster		convergence cluster	
	(1) OLS		(2) ML		(3) ML		(4) OLS	
	parameter	prob[b]	parameter	prob[b]	parameter	prob[b]	parameter	prob[b]
Constant	0.073	0.12	0.069	0.13	0.094	0.06	0.017	0.79
productivity 1993	-0.005	0.26	-0.005	0.13	-0.006	0.14	-0.008	0.10
growth neighbors[c]	—		0.273	0.00	—		—	
residuals neighbors[c]	—		—		0.283	0.00	—	
productiv. neighbors[c]	—		—		—		0.008	0.21
Moran's I[e, i]	0.15(N)	0.00	.		.		0.15(N)	0.00
LM_{ERR}[f, i]	3.27(N)	0.07	2.12(D)	0.14	.		2.83(N)	0.09
LM_{LAG}[g, i]	2.65(N)	0.10	.		3.40(D)	0.07	2.13(N)	0.14
LR-test: significance of spatial dependence[h]	—		13.20	0.00	14.00	0,00	1.60	0.21
common factor hyp.[j]	—		—		2.80	0.09	—	
no of regions	327		327		327		327	
R²(adj.)	0.00		.		.		0.00	
log-Likelihood	1082.8		1089.4		1089.8		1083.6	
AIC[d]	-2161.7		-2172.8		-2175.6		-2161.3	

[a] Cross-section regressions for 112 East German counties; dependent variable: average annual productivity growth rate 1992/94 – 1998/2000. – [b] Error probability. – [c] Direct neighbors (with a common border). – [d] Akaike information criterion. – [e] Moran's I test for spatial dependence. – [f] Lagrange Multiplier test for spatial autocorrelation. – [g] Lagrange Multiplier test for spatial lag dependence. – [h] Likelihood-Ratio test for respective kind of spatial dependence (vis-a-vis the basic model (1). – [i] Table reports only test with lowest error probability; alternative spatial weights: N: direct neighbors (first-order binary contiguity), D: inverse distances up to 60 km. – [j] LR test of the common factor hypothesis.

parameter ('productivity 1993') which has been estimated to be negative and highly significant for East Germany turns out to be insignificant for West Germany. Taking into consideration the possible bias due to Galton's fallacy it can be concluded with some confidence that there was no convergence in regional productivities in West Germany during the 1990s. The problem in the present context, however, is that the basic model which worked fairly well for East Germany has very limited explanatory power for West Germany; the R^2 is virtually zero! Since the basic model fails completely in capturing the driving forces of regional growth in West Germany it can hardly be expected to be useful for detecting neighborhood effects.

Nonetheless, continuing the analysis for the sake of completeness – bearing in mind that the results may be highly ambiguous – we find some vague indication for spatial dependence being relevant for West German regions as well. The nature of dependence, however, seems to be different from that in East Germany: Both the local growth, and the local shock cluster approaches (columns 2 and 3) come along with a significant improvement of explanatory power vis-à-vis the basic model. And in both approaches the estimated parameter for the spatially lagged variables indicate significant spatial dependence. The convergence cluster approach (column 4), by contrast, which appears to be highly relevant for East Germany, seems to be irrelevant for West Germany.

To discriminate between the growth and the shock cluster model a LR test of the so-called ‘common-factor hypothesis’ (eq. 5) can be employed. The test statistic which is reported in column (3) does not reject the shock cluster approach at the 5 per cent level. Although the error probability of prob=0.09 is not too comfortable we might prefer the shock over the growth cluster approach.

3. The role of growth poles

Having identified the form and intensity of spatial interdependencies between all regions – resp. between some sort of a representative region and its representative neighbor – we can use it as a benchmark for the evaluation of spatial externalities originating from perceived growth poles. Because of the poor reliability of the empirical results for West Germany we will concentrate on East Germany. According to the theoretical concept of growth poles these agglomerations should produce particularly strong growth impulses to the benefit of their neighbors in space. The hypothesis to be tested in the present paper thus is that these growth impulses are significantly stronger than those estimated above for a representative East German region.

In the literature two attempts have been made to identify growth poles in East Germany. Selke (1991) argues that the five regions around Berlin, Dresden, Magdeburg, Halle/Leipzig and Erfurt/Jena should have favorable prospects for becoming growth poles. More recently the German Council of Economic Advisors (Council 1999) has identified seven labor-market regions as growth poles, namely Leipzig, Dresden, Halle, Jena, Erfurt, Chemnitz, and Berlin.[31] The results of a cluster analysis – combining various statistical indicators for endowment with physical, human, and infrastructure capital, productivity level, share of service industries, externalities of agglomeration, and accessibility from German and European centers, among others – suggest these seven regions to have a particular high potential for economic growth.

Following the more recent study by the Council we assume these seven regions to be potential growth poles in the present empirical investigation. In order not to loose too many degrees of freedom we prefer staying at the level of counties rather than using the broader labor-market regions as units of analysis. That is, we assume all counties sharing a border with the above-

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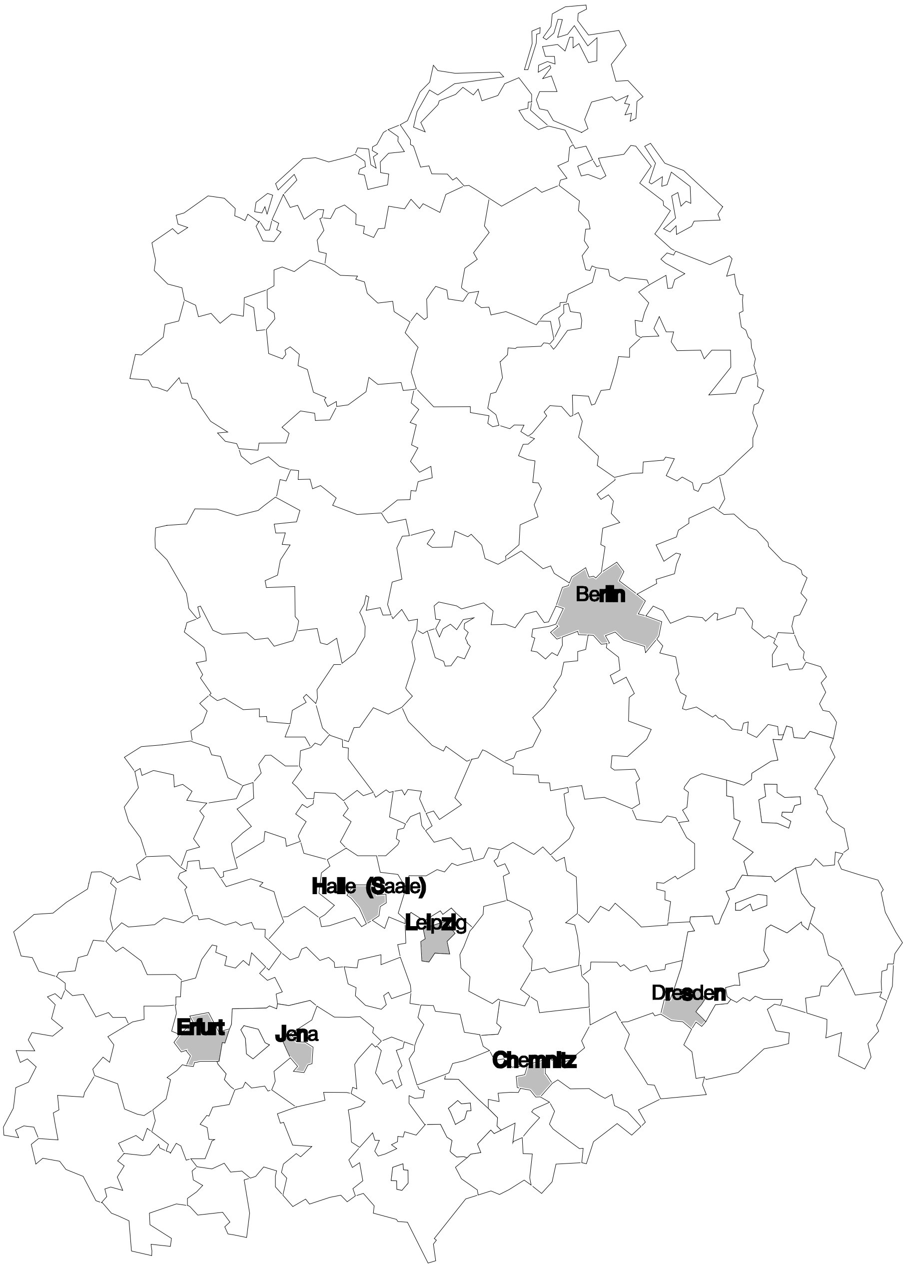
31 Apart from the central cities, which are counties on their own, the respective labor-market regions usually comprise two or three neighboring counties with particular strong commuting flows to the cities.

mentioned pole-cities (Figure 1) to be ‘recipients’ of spatial spillovers from the poles even if they are parts of the labor market regions identified as growth poles.[32]

Figure 1 — Core cities of growth poles in East Germany



Source: Council (1999).

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[32] This modification of the spatial scope of growth poles should not affect the reliability of results. In fact it should be the central cities rather than their hinterlands who produce spatial externalities. The opposite would question the concept of growth poles as a whole. Taken this way, the concentration on central cities is nothing but a sharpening of the focus.

To estimate the influence if growth poles on counties in their spatial proximity we construct an additional explanatory variable defined as the weighted average of the productivity levels of the growth poles. Conceptually, this variable is similar to the one used for describing local convergence clusters in the preceding section, the only differences being that in the respective spatial weights matrix positive entries are restricted to those regions (rows) who are defined as neighbors of growth poles, and to those neighbors (columns) who are defined as growth poles. The extended empirical model thus reads

$$\hat{y}_r = \beta_0 + \beta_1 \ln y_r + \delta \sum_{\substack{s \in R_r \\ s \neq r}} w_s \ln y_s + \phi \sum_{\substack{j \in G_r \\ j \neq r}} w_j \ln y_j + u_r \,; \tag{6}$$

$$\sum_{\substack{s \in R_r \\ s \neq r}} w_s = \sum_{\substack{j \in G_r \\ j \neq r}} w_j = 1 \,.$$

Since, again, two alternative spatial weights (first-order binary contiguity or inverse distances) are used, G_r in (6) is the set of growth poles that either share a common border with *r*, or are within a distance of up to 60 km from *r*. If the growth impulses sent out by the poles are higher than the general neighborhood effects estimated by the local convergence cluster model above the parameter ϕ of the additional variable will be significantly positive while the parameter δ reflecting the convergence cluster effects might diminish somewhat.[33]

The empirical results, reported in column (2) of Table 3,[34] clearly indicate that spatial spillovers originating from the seven East German growth poles identified by the Council are neither stronger nor weaker than those originating from all East German regions on average. The respective parameter (‘growth pole effects’) is estimated to be very low ($\hat{\phi}$ =-0.0003), has a wrong, negative sign, and is not different from zero at the 10 per cent level. Moreover, The AIC does not indicate any improvement of explanatory power vis-à-vis the local convergence cluster model, and the additional variable does not affect the other parameter estimates to a notable extent. Even the parameter reflecting convergence cluster effects remains (almost) the same. Quite surprisingly, however, the LM tests indicate that there may be some spatial dependence left unexplained. But test regressions which are not reported here suggest that this correlation is spurious. There is neither significant spatial autocorrelation nor spatial lag dependence. This also means: Neither expected nor unexpected productivity growth in the growth poles has a significant effect on their respective neighbors.

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33 The latter would even turn insignificant if the spatial dependence interpreted as local convergence so far was dominated by spillovers from the poles.

34 For a better comparison, the benchmark regression (column 4 in Table 1) is repeated in column (1) in Table 3. Reported are only the results for the first-order binary contiguity concept of neighborhood. The results for growth pole effects based on inverse distance weights are similar.

Table 3 — Tests for spillover effects from growth poles for East German counties 1992/94–1998/2000[a]

	convergence cluster		growth poles	
	(1) OLS		(2) OLS	
	parameter	prob[b]	parameter	prob[b]
Constant	0.655	0.00	0.637	0.00
productivity 1993	-0.081	0.00	-0.081	0.00
productivity neighbors:				
convergence cluster effects[c]	0.025	0.02	0.026	0.01
growth pole effects[c]	—		-3.0E-4	0.11
dummy Hoyerswerda	-0.028	0.00	-0.029	0.00
Moran's I[e. h]	0.03(D)	0.38	0.37(D)	0.40
LM_{ERR}[f. h]	1.97(N)	0.16	4.10(N)	0.04
LM_{LAG}[g. h]	1.89(N)	0.17	4.06(N)	0.04
no of regions	112		112	
R^2(adj.)	0.47		0.48	
Log-Likelihood	365.5		366.8	
AIC[d]	-723.0		-723.6	

[a] Cross-section regressions for 112 East German counties; dependent variable: average annual productivity growth rate 1992/94 – 1998/2000. – [b] Error probability. – [c] Direct neighbors (with a common border). – [d] Akaike information criterion. – [e] Moran's I test for spatial dependence. – [f] Lagrange Multiplier test for spatial autocorrelation. – [g] Lagrange Multiplier test for spatial lag dependence. – [h] Table reports only test with lowest error probability; alternative spatial weights: N: direct neighbors (first-order binary contiguity), D: inverse distances up to 60 km.

4. Conclusions

Summing up we have, first, found empirical evidence for significant neighborhood effects among regions within East Germany during the 1990s which take the form of local convergence clusters rather than local growth, or shock clusters: Regions with, on average, rich neighbors ceteris paribus have experienced faster productivity growth than those with poor neighbors. These effects have been in excess of a general tendency towards regional productivity convergence. I.e., within the general tendency for poor East German regions to catch up vis-à-vis richer ones, those who were clustered spatially with other poor regions have been faced with some sort of a handicap: They have tended of grow significantly slower than equally poor regions who happened to have richer neighbors. Conversely, within the general tendency for rich regions to return to East German mediocrity, those who were clustered spatially with other rich regions have tended to return at a slower pace than those who happened to have poorer neighbors.

For West Germany, things seem to be different. Although there is some evidence for neighborhood effects being relevant in West Germany as well, they seem to take the form of local shock rather than convergence clusters. At the same time, there is no evidence of any productivity convergence among West German regions. These results are, admittedly, not too reliable since the convergence regression approach adopted in the present investigation fails in describing regional growth patterns in West Germany appropriately. But they are broadly in line with more reliable results obtained for other highly industrialized countries like the U.S. (Rey, Montouri 1999), and for Europe as a whole (Baumont et al. 2000).

By its nature the convergence analysis undertaken in the present paper is not informative as to the driving economic forces behind the observed general patterns of regional development, and the different types of local correlation.[35] The evidence might, however, suggest that both the pattern of regional convergence, and the form of neighborhood externalities tend to change in the process of economic development:

In emerging market economies, or at least in economies like the East German one which have been transiting from a socialist to a market economy the regional income and productivity distributions can be expected to be in a state of flux. With most regions still being in search of their comparative advantages, and with regional income differences still being quite high, lagging regions have the opportunity to learn from, and to imitate more successful ones. The extension of the industrial base plays an important role: A large number of new firms is created, be it by domestic entrepreneurs exploiting new income opportunities, or be it by foreign firms taking advantage of low costs of production, or exploiting the emerging markets. At this stage local networks, and close forward and backward linkages across regional borders – through which economic shocks often are transmitted – might be scarce. In such a phase of economic development regional convergence may prevail, and local convergence clubs may result from a certain spatial clustering of start-ups, and from localized learning.

In the course of ongoing economic development the regional income distribution might converge towards some sort of an equilibrium. Regional income differences diminish as regions increasingly specialize according to their comparative advantages, and the number of start-ups decreases while the expansion of existing firms gains importance as a driving force of regional growth. The division of labor at the local level is intensified as agents discover potentials for synergies within productivity-enhancing local networks. In this phase the speed of regional income convergence can be expected to slow down, and local convergence clus-

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[35] In fact, convergence analysis is descriptive in the first line. Its comparative advantage lies in identifying and describing regularities in the evolution of income distributions, and in detecting problematic developments like poverty traps and lock-ins. An economic explanation of what has been observed must be left to other methods, like theory-based hypothesis testing, or detailed case studies.

ters may turn into shock clusters as the potential for regional income convergence fades away, and as local forward and backward linkages are intensified.

In mature, highly developed market economies, finally, where the regional income distribution has become fairly rigid (at least in the medium-term perspective of, say, one decade), and where economic agents have had largely exploited the opportunities of productivity-enhancing collaboration, the potential for regional income convergence can be expected to be low, and economic interaction between regions might be affected by economic shocks in the first line.

Of course, this is nothing but a hypothesis. Further, more detailed research is needed to verify, resp. falsify it. This research should aim at both developing a theoretical framework which is able to explain the pattern and the evolution of regional interaction in the course of economic development, and gathering more empirical evidence on how, and to what extent regions interact.

Second, the empirical evidence presented in this paper suggests that those cities perceived as growth poles by the German Council of Economic Advisors in his annual report 1999/2000 have – on average – not played an outstanding role in producing spatial externalities to the benefit of their neighboring regions during the 1990s. Although the prospects for economic growth have been most promising in these cities, given their endowment with human, physical, and infrastructure capital, their high productivity level, and their good accessibility from major markets, they have, on average, neither grown faster themselves nor produced stronger spatial externalities in terms of productivity growth to the benefit of their neighbors than other regions. In the light of the hypothesis on changing patterns of neighborhood effects in the course of economic development sketched above this might be due to fact that local networks are largely lacking even in the agglomerations. Obviously, the few exceptions, some of which have been mentioned in the introduction, are not sufficient to conclude that agglomerations behave significantly different from other regions.

Given the empirical evidence currently available, a concentration of public aid towards East Germany onto agglomerations can hardly be justified. It is not clear whether more public aid will really help them exploiting their favorable growth potentials. And even if this happened it is not clear to what extent prosperous agglomerations would produce spatial externalities for their neighbors which are sufficiently large for East Germany to benefit as a whole. Again, however, this conclusion is based on just an empirical observation drawn from an analysis of perceived, potential growth poles. Future research should aim at explaining in detail why those seven agglomeration have failed it exploiting their favorable growth potentials. And it should aim at identifying growth poles endogenously rather than exogenously, i.e., at assessing neighborhood effects of those agglomerations that do not just have favorable growth potentials in theory but have really experienced above-average economic dynamics.

References

Anselin, L. (1988), *Spatial Econometrics: Methods and Models*, Dordrecht: Kluwer.

— (1995), *SpaceStat Version 1.80 User's Guide*.

— , A.K. Bera, R.J. Florax, M.J. Yoon (1996), Simple Diagnostic Tests for Spatial Dependence, *Regional Science and Urban Economics* 26: 77–104.

— , R.J. Florax (1995), Small Sample Properties of Tests for Spatial Dependence in Regression Models: Some Further Results, In: L. Anselin, R.J. Florax (eds), *New Directions in Spatial Econometrics*, Berlin: Springer.

— , S. Rey (1991), Properties of Tests for Spatial Dependence in Linear Regression Models, *Geographical Analysis* 23 (2): 112–131.

— , A. Varga, Z.J. Acs (2000), Geographic and Sectoral Characteristics of Academic Knowledge Externalities, *Papers in Regional Science* 79 (4): 435–443.

Barro, R.J., X. Sala-i-Martin (1991), Convergence, *Journal of Political Economy* 100 (2): 223–251.

— (1995). *Economic Growth*. New York: McGraw-Hill.

Baumont, C., C. Ertur, J. Le Gallo (2000), Geographic Spillover and Growth – A Spatial Econometric Analysis for European Regions. Paper presented at the 2000 RSAI World Congress, Lugano, May 16-20, 2000.

Bickenbach, F., E. Bode (2001), Markov or not Markov – This should be a question, Kiel Working Paper No. 1086, Kiel Institute of World Economics.

Blien, U., K. Wolf (2002), Regional Development of Employment in Eastern Germany. An Analysis with an Econometric Analogue to Shift-Share Techniques, Forthcoming in *Papers in Regional Science*.

Bode, E. (2001), Is Regional Innovative Activity Path-dependent? An Empirical Analysis for Germany, Kiel Working Paper No. 1058, Kiel Institute of World Economics.

Bode, E. (2002), R&D, Localized Knowledge Spillovers, and Endogenous Regional Growth: Evidence from Germany, In L. Schätzl, J. Revilla Diez (eds.), *Technological Change and Regional Development in Europe*. Heidelberg: Physika.

Bottazzi, L., G. Peri (2000), Innovation and Spillovers: Evidence from European Regions, CESifo Working Paper 340, Munich.

Boudeville, J.R. (1966), *Problems of Regional Economic Planning*, Edinburgh: Edinburgh UP.

Büttner, T. (1999), The Effect of Unemployment, Aggregate Wages, and Spatial Contiguity on Local Wages: An Investigation With German District Level Data, *Papers in Regional Science* 78 (1): 47–67.

Deutsches Institut für Wirtschaftsforschung (DIW), Institut für Weltwirtschaft an der Universität Kiel (IfW), Institut für Arbeitsmarkt und Berufsforschung (IAB), Institut für Wirtschaftsforschung Halle (IWH), Zentrum für Europäische Wirtschaftsforschung (ZEW) (2002), Fortschrittsbericht über die wirtschaftliche Entwicklung in Ostdeutschland. Research Project commissioned by the German Ministry of Finance. Berlin.

DiNardo, J., J. L. Tobias (2001), Nonparametric Density and Regression Estimation, *Journal of Economic Perspectives* 15 (4): 11–28.

Durlauf, S.N., D.T. Quah (1999), The New Empirics of Economic Growth, In: Taylor, J.B. (ed.), *Handbook of Macroeconomics*, Vol. 1A, Amsterdam: Elsevier.

Enright, M. (2001), Regional Clusters: What We Know and What We Should Know. Paper presented at the Workshop "Innovation Clusters and Interregional Competition", Kiel, November 13, 2001 (available at http://www.uni-kiel.de/ifw/konfer/innovation/inno.htm).

Fingleton, B. (1999), Estimates of Time to Economic Convergence: An Analysis of Regions of the European Union, *International Regional Science Review* 22 (1): 5–34.

— , J.S.L. McCombie (1998), Increasing Returns and Economic Growth: Some Evidence for Manufacturing from the European Union Regions, *Oxford Economic Papers* 50 (1): 89–105.

Friedman, M. (1992), Do Old Fallacies Ever Die? *Journal of Economic Literature* 30 (4): 2129–2132.

German Council of Economic Advisors (Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung) (1999), *Wirtschaftspolitik unter Reformdruck*, Jahresgutachten 1999/2000, Wiesbaden.

Greunz, L. (2002), A Panel data Analysis of Geographically and Technologically Medated Knowledge Spillovers Between European Regions, Paper presented at the 41th Annual Meeting of the Western Regional Science Association, Monterey, February 17-20, 2002.

Kehrer, G. (2000), Industriestandort Ostdeutschland, Berlin: Fides.

Niebuhr, A. (1999), *Räumliche Wachstumsstrukturen: Theoretische Erklärungsansätze und empirische Befunde für die Bundesrepublik Deutschland*, Munich: Florentz.

Perroux, F. (1955), Note sur la Notion de Pôle de Croissance, *Economie Appliquée* 7 : 307–320.

Quah, D.T. (1993a). Galton's Fallacy and Tests of the Convergence Hypothesis. *Scandinavian Journal of Economics* 95 (4): 427–443.

Ragnitz, J., G. Müller, A. Wölfl and others (2001), *Produktivitätsunterschiede und Konvergenz von Wirtschaftsräumen – Das Beispiel der neuen Länder*, IWH-Sonderheft 3/2001, Halle.

Rey, S. (2001a). Spatial Dependence in the Evolution of Regional Income Distributions. Paper presented at the 40th Annual Meeting of the WRSA, Palm Springs, Ca.

Rey, S. (2001b). Spatial Empirics for Economic Growth and Convergence. *Geographical Analysis* 33 (3): 195–214.

—, B.D. Montouri (1999). US Regional Income Convergence: A Spatial Econometric Perspective. *Regional Studies* 33 (2): 143–156.

Richardson, H.W. (1979), *Regional Economics*, Urbana: University of Illinois Press.

Selke, W. (1991), Raumordnungspolitische Aufbaustrategie für den Osten Deutschlands. Das raumordnerische Konzept für den Aufbau in den neuen Ländern, *Informationen zur Raumentwicklung* (9/10): 747–753.

Statistisches Landesamt Baden-Württemberg (2001), Bruttoinlandsprodukt, Bruttowertschöpfung in den kreisfreien Städten und Landkreisen der Bundesrepublik Deutschland 1992, 1994, 1996 und 1998 – revidierte Ergebnisse nach ESVG 1995. Stuttgart.