Regional ICT industries growth: Common prejudices and empirical evidence

by

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1. Introduction

Many advocates of an active regional economic policy tend to consider regional sectoral concentration as something which can be created, as a recipe rather than just a development which sometimes occurs and sometimes not. Whether such a policy can be successful implicitly depends on a number of assumptions which are empirically tested in this paper:

The first assumption is that regional concentration and regional specialisation foster growth. We test this hypothesis, using data for ICT employment in 97 German regions (section 2.1).

Second, the common perception is that East Germany is still a special case. This is clearly supported for the ICT industry, which lacks behind not only with respect to level, but also with respect to (employment) growth rates for 1995 to 2002.

Third, if regional sectoral agglomeration is an advantage for regions due to technological externalities, for example, then the same reasons might lead to spillover effects between neighbouring regions. We ague that these spillovers might both be negative and positive, hence the empirical evidence provided in section 2.2. is of particular interest.

Forth, we investigate whether regional economic policy has a positive impact. Again using spatial econometrics techniques, not so standard in this case, our results reported in section 2.3. show that the 16 German Laender seem not able to do change the path which is determined for the ICT industries by spatial and other variables.

2. Hypotheses and some preliminary empirical evidence

2.1. Regional concentration and specialisation

Basically there are two concepts of "agglomeration": one is simply a densely populated area, and the reasons why these agglomerations should be successful are discussed as "urbanisation economies" (or Jacobs externalities). We do not consider these in the present paper, however, as regional economic policy cannot - at least not in the short run and not to a large extent - change the regional population density, and we follow the public debate in focussing on a certain sector which is presumed to be of key importance: the ICT sector.

In other words, we focus on the second concept of "agglomeration" - sectoral regional concentration, the prime example being Silicon Valley. It became so popular as a policy "brandname" that a German cluster of producers of musical instruments has been named "Musicon Valley" (http://www.musiconvalley.de), for example[1].

In a narrow sense, rather than regional concentration we measure regional specialisation: The number of employees of a certain sector in region i, divided by the total employment in region i. Using this share as an indicator for concentration has an obvious theoretical disadvantage: Presume a certain region is completely empty with the sole exception of one firm, then it is extremely specialised, but there is no sectoral agglomeration as the firm is standing alone rather than in close neighbourhood with other firms of the same sector. Nevertheless, empirically regional concentration and regional specialization neatly correlate, and in most cases, an increase in sectoral specialisation will lead to potential agglomeration economies in this sector. Basically three types of advantage of economic concnetration in space can distinguished: Pecuniary externalities, such as local availability of suppliers for specific intermediate goods, technological externalities such as knowledge spillovers or common use of infrastructure, and labour pooling - i.e. an attractive reservoir of potential employees.

Hence our first hypotheses is: Regional sectoral specialization leads to higher growth rates of employment in that sector.

Basically there are two approaches to measuring employment in industries. The more common is to classify firms into industries. All employees of these firms then count as working in the respective industry (a secretary working in the chemical industry is parted as part of this industry, a secretary working for a law for is counted as working in the legal advise business). Throughout this version[2] of our paper we use the alternative approach: Each employee is assigned an occupation, and the size of an industry in a region is measured by the number of people actually working in the respective occupation. These data are provided by the Institute for Employment Research ("IAB"),

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[1] Other examples, all from Germany: Medical Valley Hechingen (http://www.regionalverband-neckar-alb.de/projekte/medical-valley.htm), Medical Valley Erlangen (http://www.izmp-erlangen.de/medicalvalley.html), BioCon Valley (http://www.bcv.org/english/index_engl.html) and Measurement Valley, Göttingen (http://www.measurement-valley.de).

[2] In the next draft we will replicate the results for occupation data with industry data.

the German Federal Employment Services' ("Bundesagentur für Arbeit") research institution. We consider the following occupations:

- advertising experts
- computer expert personnel
- electrical engineers
- electrical engineering technicians
- natural scientists
- printers
- publicists
- telecommunication personnel

All of these occupations are concentrated in space, in the following sense: We considering the 97 German "planning regions" (Raumordnungsregionen), and take the 10 regions with the highest number of employees in the respective occupation. Then the cumulated share of these 10 regions in the number of employees in the occupation is much larger than their share in labor force (table 1).

Table 1: Regional concentration in ICT occupations

	For the 10 largest regions (of 97) with respect to occupation's employment:		
Occupation	Cumulated share of labour force in this occupation	Cumulated share of overall GDP	Cumulated share of total labour force
advertising experts	0.60	0.32	0.26
computer expert personnel	0.52	0.33	0.26
electrical engineers	0.55	0.32	0.25
electrical engineering technicians	0.46	0.35	0.27
natural scientists	0.48	0.29	0.24
printers	0.36	0.36	0.29
publicists	0.60	0.26	0.33
telecommunication personnel	0.35	0.28	0.35

The cumulated share of overall GDP and of total labour force for the largest 10 is not equal across occupations, as the group of the largest 10 is not equal for these[3]. Concentration in this sense is normal and occurs for many industries (though not for some services which are distributed just like labour force, such as hair dressing). Noteworthy but also not surprising is that these ICT regions have a higher share in GDP than in labour force, i.e., they are "richer". However, there is one thing which is not ex ante clear and which needs to be investigated in closer detail: The ICT industry might or might not grow faster where it is clustered. One could make sense of both observations.

First, according to the "Death of Distance" hypothesis (Cairncross, 2001), information and communication technologies make it possible for geographically isolated firms to interact with others as if they were close. Arguably the use of these modern technologies became especially important within the ICT industry itself, and if this made distance between firms a lesser problem since 1995, then rural areas should have gained, and growth rates should be greater there.

Second, local networks, which are in need of a minimum degree of agglomeration, might become increasingly important. A highly disaggregated industry structure, sometime referred to as "flexible specialization" (Piore and Sabel, 1984), is beneficial for very differentiated goods or project-by-project services, as it allows a flexible choice of input suppliers who use more or less flexible general-purpose technologies. This mode of production relies on working relationships within networks, however. The point that these are much easier to achieve in the case of local sectoral concentration is made by Scott, 1984, Storper, 1989, and Storper and Scott, 1990, for the case of the motion pictures industry in Los Angeles. "Flexible specialisation" requires a higher share of different ("contingent") employment relationships, something which is indeed to be found more often in agglomerations, see Neumark and Reed (2004) for the new economy sector. If it is true that "flexible specialisation" is of increasing importance, then this surely also holds for the innovative and dynamic ICT industries we consider. Then we should observe an increasing local concentration of these.

[3] The four regions being among the top 10 lists for all occupations are: Berlin, Hamburg, Munich, Rhein-Main.

Table 2: OLS regressions of regional sectoral growth on regional concentration

	dependent variable							
	GR_PRINT	GR_ADV	GR_COMP	GR_EING	GR_ETECH	GR_NATSCI	GR_PUBL	GR_TELECOM
C_PRINT	-0.0030 (-1.39)							
C_ADV		0.0054 (1.52)						
C_COMP			-0.0016 (-1.30)					
C_EING				-0.0014 (-0.67)				
C_ETECH					-0.0086 (-2.59)			
C_NATSCI						-0.0143 (-1.03)		
C_PUBL							0.0034 (0.99)	
C_TELECOM								-0.0307 (-5.75)
EAST	0.0141 (2.90)	-0.0285 (-8.65)	-0.0214 (-3.89)	-0.0310 (-5.17)	0.0041 (0.64)	-0.0056 (-0.38)	-0.0227 (-2.87)	-0.0074 (-0.54)
PATHAB	-0.0065 (-1.03)	0.0099 (2.05)	0.0053 (0.59)	0.02565 (2.32)	0.0309 (2.73)	0.0295 (1.35)	-0.0029 (-0.25)	-0.0173 (-1.09)
R^2	0.30	0.60	0.19	0.41	0.09	0.04	0.12	0.41

N = 97; t-statistics in parentheses

We can simply test this by regressing sectoral regional growth on sectoral regional concentration. More specifically, GR_ADV is the average yearly growth of employment from 1995 to 2002 in the advertising sector, observed for 97 regions, and likewise GR_COMP for computer expert personnel, GR_EING for electrical engineers, GR_ETECH for electrical engineering technicians, GR_NATSCI for natural scientists, GR_PRINT for printers, GR_PUBL for publicists, GR_TELECOM for telecommunication personnel. The concentration (denoted C_ADV etc.) is measured as employment in the respective sector in 1995, divided by total workforce. EAST is a dummy variable for regions in the former GDR, including Berlin. PATHAB is a control variable measuring the number of patents per capita (in 1999).

In almost all cases, it turns out (table 2), the coefficient of the concentration variable is negative, including the only two cases where it is significant. Hence we do not find support for the "concentration promotes growth" hypothesis. This result cannot be explained by a temporary catching up of the "new" (East German) Laender, as this effect would be controlled for through the dummy variable EAST (which does not suggest a catching up anyway, except in the case of printing).

2.2. Does regional neighbourhood matter? Backwash effect versus spread effect

So far we have only focused on agglomeration economies within single regions, neglecting the arrangement of regions in space. However, if regional sectoral agglomeration is an advantage for regions due to technological externalities, for example, then the same reasons might lead to spillover effects between neighbouring regions. Growth of a sector in region A might foster growth is the neighbouring region B, for reasons such as firms in B supplying inputs for firms in A, or because of knowledge spillovers from A to B. With Myrdal (1957) one might call this a "spread effect". However, the opposite, called "backwash effect" by Myrdal, is also well possible: If a certain sector is growing in region A, hence becoming more attractive location for the sector, which firms are most likely to move to A? Arguably firms from region B. Hence, it is not at all clear ex ante whether regions grow at the expense of their neighbouring regions, or whether they generate positive externalities for these. This question must be answered by an empirical investigation, allowing for the possibility that the "backwash" effect might dominate in some sectors, whereas the spread effect dominates in others.

Simply regressing each region's growth rate on the average of the neighbours' growth rates is impossible, as evidently the regressand has an impact on the explanatory variable, which is why one also speaks of "spatial autocorrelation", even though usual tests for autocorrelated time series are not applicable either. Hence we use a set of tools developed in the *spatial econometrics* branch.

Uneven specialisation in industries as we reported above is one common measure in regional economics. A related and stronger type is when specialisation patterns are contagious across regions. This would result in an economic landscape in which neighbour regions tend to be similar to each other. In order to test for this we make use of a distance weights matrix of the following type:

$$W_{ij} = \frac{1/w_{ij}}{\sum_j 1/w_{ij}}$$

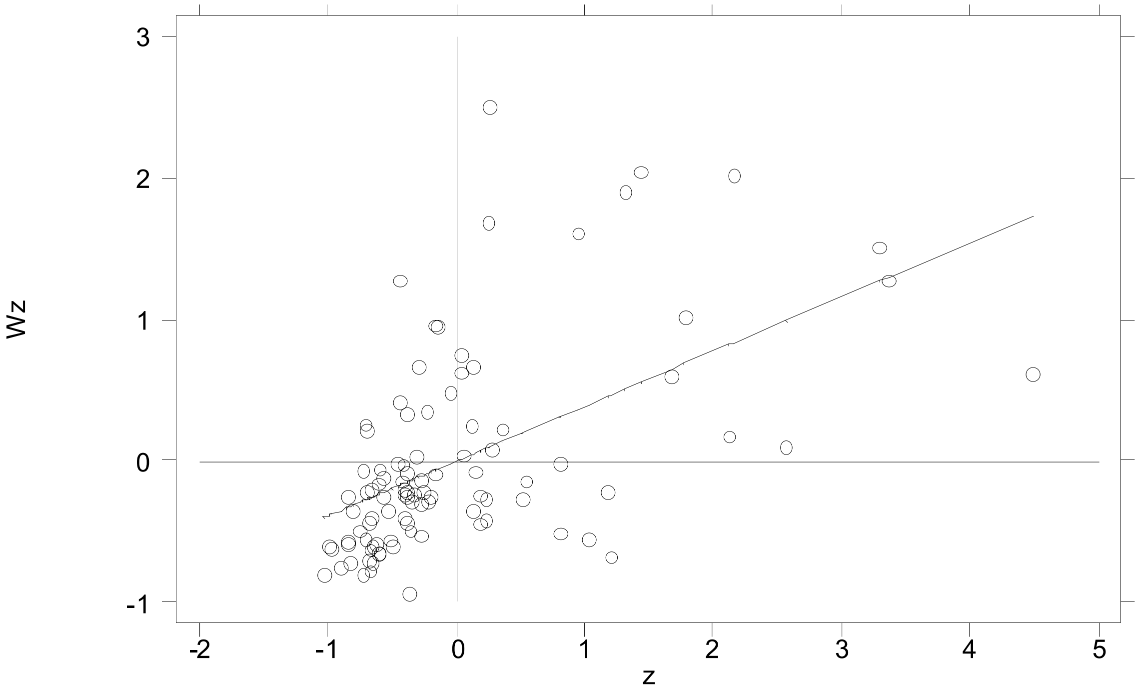
Above w_{ij} is a measure of the distance between region i and region j. The variable W_{ij} is therefore a function of the inverse of the distance between region i and j. This inverse distance measure is normalised with the sum of all such distances between region i and the other regions. This ‘row-standardisation’ makes it possible to construct weighted averages. In spatial econometrics analyses, the hypothesis is very often that a variable in one region will influence on a variable in another region as a negative function of the distance between the two regions. This is what the variable W_{ij} expresses. The distance variable, w_{ij}, can be constructed in different ways. Often geographical distance is used. Here we use contiguity between regions. That is, spatial spillovers are measured on the basis of neighbourhood between regions. Consider region j’s employment specialisation in a sector k, s_{jk} (normalised as deviations from the mean). For region i the variable

$$\bar{s}_{ik} = \sum_j W_{ij} s_{jk}$$

denotes the weighted average of that region’s neighbours’ employment in sector k.

In figure 1 we graph this variable for the share of computer experts in the region's total workforce against each regions’ performance in the same variable. These plots are called Moran scatter plots. Dots in the Northeast quadrant represent regions with both a relatively high share of employees working as computer experts and neighbours who are similar in this respect. Likewise, the third quadrant shows regions with an below-the average share of computer workers, and with neighbours who also do not at all specialize in this sector. As the first and the third quadrant. Clearly more dots are located in the first and in the third sector than in the other two, hence a simple regression has a positive slope, which is measured as the so called "Moran's I", the most common measure for spatial autocorrelation.

Figure 1: Moran scatter plot for share of computer experts in total workforce, 2001



This picture is not very surprising, given the cluster of rich regions in the Southwest of Germany, and the Cluster of regions still being behind in the East of Germany. As explained above, it is less clear ex ante how a Moran Scatter Plot looks if levels rather than growth rates are considered. Figure 2 shows that neighbourhood effects are then much less clear for the case of computer experts, and Figure 3 shows that a regions' growth and their respective neighbours' growth seem not at all to be correlated in the case of electrical engineering technicians.

Figure 2: Moran Scatter plot for growth in the number of computer experts, 1995-2002

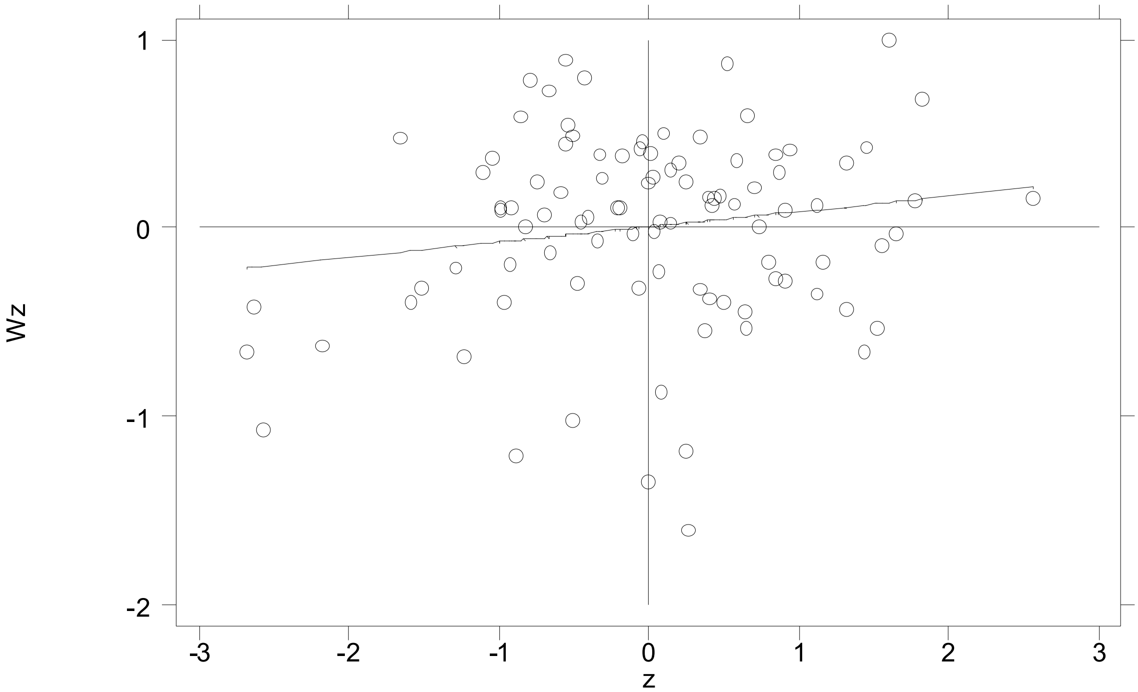


Figure 3: Moran Scatter plot for growth in the number of electrical engineering technicians, 1995-2002

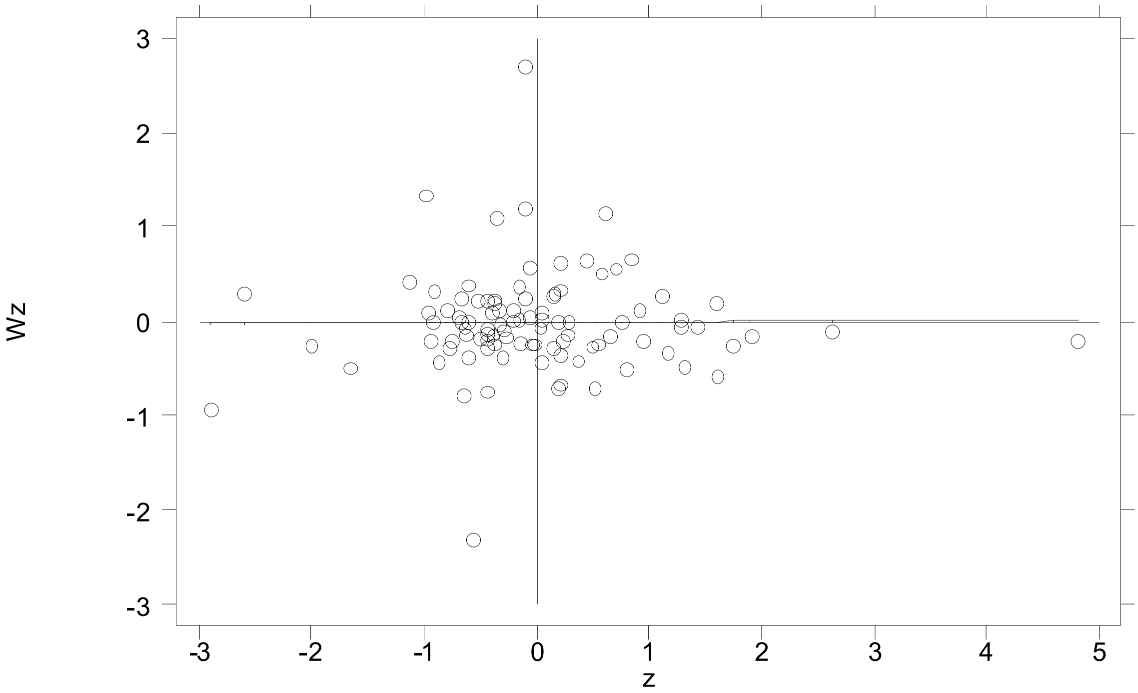


Table 3: Neighbourhood effects: level of concentration versus growth rates		
	Moran's I for...	
occupation	share in region's workforce	growth rate
advertising experts	0.342***	0.109**
computer expert personnel	0.387***	0.081*
electrical engineers	0.159***	0.191***
electrical engineering technicians	0.471***	0.006
natural scientists	0.098**	-0.011
printers	0.500***	0.138***
publicists	-0.041	0.117**
telecommunication personnel	0.338***	0.050

*, ** and *** denote significance at the 10, 5 and 1 percent level of significance, respectively (1-tail test)

Table 3 compares the Moran's I across occupations for share and growth rate. With two exceptions, neighbourhood effects are much weaker when growth rates are considered, and in three cases, the Moran's I is not significantly different from 0. The remaining evidence, however, seems to lend support to the spread effect rather than to the backwash effect, but such a conclusion would be premature, for the following reason:

The correlations reported so far are *gross correlations* in the sense that we did not take into account how localisation of industries are influenced by other variables. For example, what seemed to be positive spillovers between neighbours might rather be different patterns of developments of regions in the East and in West Germany. Fortunately, the spatial weight matrix W_{ij} can also be used in regression-based explorations, i.e., when control variables are considered.

There are two basic approaches on how to integrate spatial correlation into regression techniques: the spatial lag model and the spatial error model. Here we use the first one, assuming spatial lags in the dependent variable in question. Such an approach assumes that in addition to ordinary explanatory variables, also the magnitude of the dependent variable in other regions influence on the dependent variable for each region. For e.g. some models of economic growth, a deduction is that regions (or countries) may benefit from growth in their neighbour regions. Formally, this assumption may be written as

(1) $$g = \alpha + \rho Wg + \mathbf{X}\gamma + u$$

(2) $$\left|\mathrm{I} - \rho \mathrm{W}\right| g = \alpha + \mathbf{X}\gamma + u$$

In eq. 1 the dependent variable g in one region is assumed to depend on the vector of explanatory variables **X** (where γ is the vector of coefficients), the constant term α, the error term u and a weighted average of g in the other regions. The weights are the same as W_{ij} above. Therefore, it is assumed that g in one region influences its neighbours with weights depending on contiguity. ρ is the spatial autocorrelation coefficient to be estimated. A reformulation of eq. 1 in matrix notation is eq. 2. Eq. 2 can not be estimated by ordinary least squares regression techniques, but has to estimated by means of a maximum likelihood procedure (see Anselin, 1988, 1992).[4]

Table 4 shows the results for three occupations with the highest significance of rho. For the others, the introduction of control variables did leave even less clear traces of spread (or backwash) effect. The control variables used in these regressions are:

DENSITY: population density

CITYSTATE: Laender comprising of only one region (Berlin, Bremen, Hamburg)

STUDENTS: Number of students per 1000 inhabitants; a proxy variable for intensity of university research which can be presumed to determine growth of ICT industries

BORDER: dummy variable taking the value 1 for regions next to a foreign border

EAST: dummy variable for East German regions

INHAB: Absolute number of inhabitants

GDP: the regional gross domestic product per capita in 1995

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[4] The other approach is to assume that spatial autocorrelation enters the error term in the regression equation:

(3) $$g = \alpha + \mathbf{X}\gamma + u$$
$$u = \lambda \mathrm{Wu} + \mathrm{e}$$

While eq. 1 and 2 expresses that g in one region influences systematically g among its neighbour regions, eq. 3 expresses that ‘errors’ in g is influenced by parallel ‘errors’ in g in other regions. The magnitude of such errors is given by the parameter λ to be estimated. This is an indication that there are local clusters for which the dependent variable are either high or low, but that this is not a general feature. In this case, the explanatory variables may be correctly specified, but errors from the predicted g will transfer to neighbours. Linear squares estimation of 3 will result in unbiased

The variance ratio is a pseudo R^2 statistic, constructed as the ratio of the variance of the predicted values of the dependent variable to the variance of the observed values.

Table 4: Estimation of spatial lag regression models for three ICT occupations

	dependent variable		
	GR_PRINT	GR_EING	GR_NATSCI
DENSITY	-7.400 (-1.93)*	-0.9320 (-0.15)	-4.350 (-0.30)
CITYSTATE	-0.003 (-0.40)	-0.000587 (-0.00)	-0.0553 (-1.87)*
STUDENTS	0.000076 (0.66)	-0.000089 (-0.47)	0.00084 (1.97)**
BORDER	0.00030 (0.10)	0.00707 (1.43)	0.0202 (1.79)*
EAST	0.0176 (3.18)***	- 0.035 (-3.85)***	-0.0118 (-0.64)
INHAB	-0.000179 (-0.53)	0.000215 (0.39)	0.000238 (0.19)
GDP	-0.00113 (-1.96)**	-0.00040 (-0.42)	0.000475 (0.22)
constant	-0.00376 (-0.35)	0.01318 (0.80)	-0.00725 (-0.19)
rho	-0.2515 (-1.59)	0.1886 (1.30)	-0.3209 (-1.91)*
Variance ratio	0.440	0.386	0.121

z-statistics in parentheses. *, ** and *** denote significance at the 10, 5 and 1 percent level of significance, respectively

Insignificance for five of the six ICT occupations contrasts with what one expects if one believes that the spread effect or the backwash effect are of considerable importance. Nevertheless, it would be a mistake to conclude that neighbourhood effects is necessarily absent when rho is insignificant, and in one case it is significant, hence it might be worth investigating whether something can be done about them.

2.3. Policy impacts

Germany comprises of 16 *Bundesländer* or *Länder* (federal states), all of whom have their own ministries for economics and their own economic policy. The possibilities for regional economic policy on this level are limited, however, all important taxes are

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coefficients, but inference about them will be wrong. Also in this case correct inferences depend on a maximum likelihood estimation procedure.

either raised on the national level or on the county (*Gemeinde*) level. The main policy measures which can be used by the *Länder* are (Rohwer, 2002):

- Infrastructure policy
- Subsidies, especially for innovation and start-up finance
- Consulting services for small firms and reduction of bureaucratic obstacles
- Directing the aforementioned measures to regions which might develop as efficient clusters

The Länder are also responsible for education, culture and partly for environmental policy, but these can be presumed to have a marked impact on location choices only in the very long run. Anyway, the question is whether anything which the Länder can do has a certain kind of impact. To be more precise: Denoting growth of sector i in region A as g_{iA}, and assuming that regions B, C and D are the direct neighbours of region A, one would want to include growths in B, C and D in the list of variables which have an effect on g_{iA}, no matter whether the spread effect or the backwash effect dominates. The vector of control variables from region A which also might explain regional sectoral growth is X_{iA}. Hence,

$$g_{iA} = \alpha + \beta_1 \cdot g_{iB} + \beta_2 \cdot g_{iC} + \beta_3 \cdot g_{iD} + \gamma \cdot X_{iA}$$

Note that this is not an equation which could sensibly estimated by using simple OLS regression techniques, as growth in B, C and D might as well be affected by growth in A. The point that can already be seen from the above equation, however, is this: if A and B belong to one Bundesland and C and D belong to another, and if the Bundesland's economic policy has a common impact and A and B, then the coefficient β_1 should be larger than β_2 and β_3.

Unfortunately, this way of estimating shifts in coefficients, depending on dummy variables, has no counterpart in spatial econometrics. Our backdoor is this: We estimate spatial lag models with different weight matrices. The benchmark case is a matrix which gives weight 1 to neighbours and weight zero to non-neighbours, see table 4 above. We then compare this to results of regressions with matrices where neighbourhoods of regions belonging to different Länder are given a lower weight (0.1, 0.2, ..., 0.9) - let us call these weights "cross-border discount rates".

Figure 4: Printers

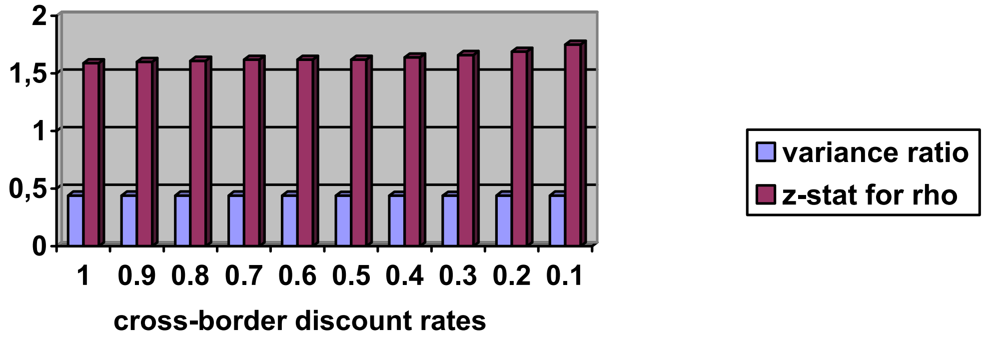


Figure 5: Electrical engineers

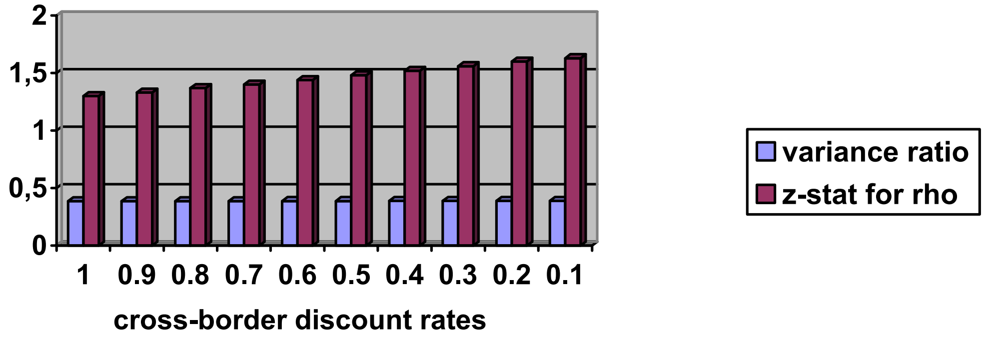
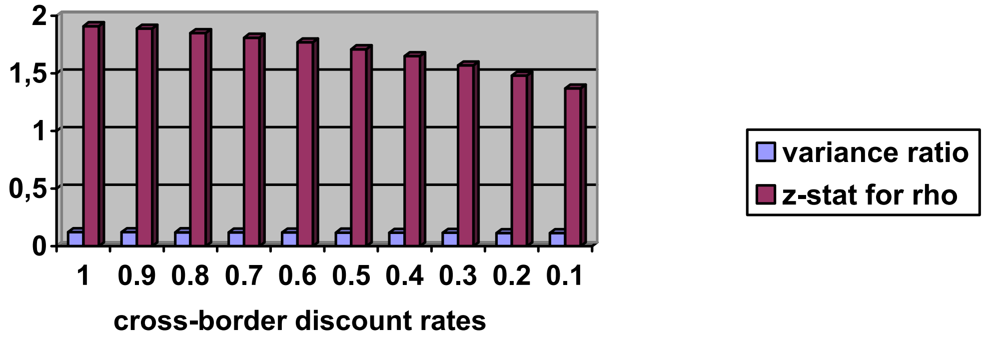


Figure 6: Natural scientists



For each of these in three occupations, figures 4, 5 and 6 report the variance ratio - admittedly breaking a fly on the wheel, as according to this measure, the goodness of fit hardly changes at all. The z-statistic for the spatial autocorrelation parameter rho, however, does change a bit when the cross-border discount rates are varied, yet the pattern is not uniform. For printers and electrical engineers, the modified weight matrix works slightly better according to this criterion (rho becoming significant at the 10 percent level from a discount rate of 0.3 on), whereas the opposite seems to be true for natural scientists. The picture is equally inconclusive when the method of varying the weight matrix is applied to the Moran's I. Figure A-1 and A-2 in the Appendix show that the (absolute value of the) Moran's I only in half of the cases increases when a difference is made between neighbourhood of regions within *Länder* and neighbourhoods across borders of *Länder*.

3. Concluding remark

ICT employment growth rates seem to cluster, but less so than levels. Introduction of control variables very much modifies this picture. The impact of the economic policy at the sub-national level is much harder to isolate, and our preliminary results suggests that the impact is small. There are at least two possible reasons for this, which might be true at the same time. One is that the economic policies of the *Länder* do not really differ much (Berthold, 2002). The other is that their policy measures are not perceived as important from the firms' perspective[5].

[5] For some survey evidence on this see Cap Gemini Ernst & Young, (2002).

References

Anselin, Luc (1988), Spatial Econometrics: Methods and Models, Kluwer Academic Publishers, London.

Anselin, Luc (1992), Spacestat tutorial, Technical Report S 92 1, National Centre for Geographical Information and Analyses, University of California, Santa Barbara, California.

Berthold, Norbert (2002), Wirtschaftspolitik in einem gefesselten Land, *Die Welt*, 5.Februar2002, http://www.wifak.uni-wuerzburg.de/wilan/wifak/vwl/vwl4/publik/Zwischenruf/Welt%2002%2002.pdf

Cairncross, Frances (2001), The Death of Distance 2.0: How the Communications Revolution Will Change our Lives. 2. Aufl., London: Texere

Cap Gemini Ernst & Young (2002), Die Unternehmerfreundlichkeit der Bundesländer im Vergleich. Kurzfassung, mimeo, http://www.impulse.de/downloads/son/kurzfassung.pdf or http://www.wirtschaftsforumberlin.de/Studie_Standortattraktivitaet_Unternehmerfreundlichkeit_2002.pdf

Myrdal, Gunnar (1957), Economic Theory and Under-Developed Regions, London: Duckworth

Neumark, David and Deborah Reed (2004), Employment relationships in the new economy, Labour Economics 11, 1-31

Piore, Michael J. and Charles F. Sabel (1984), The Second Industrial Divide, New York: Basic Books

Rohwer, Bernd (2002), Wirtschaftspolitik in Schleswig-Holstein zwischen Lehrbuch und Sachzwang, mimeo, http://www.bernd-rohwer.de/wirtschaftsminister/reden/antrittsvorl.pdf

Scott, Allen J. (1984), Territorial reproduction and transformation in a local labor market: the animated film workers of Los Angeles, Environment and Planning D: Society and Space 2, 277-307

Storper, Michael (1989), The transition to flexible specialisation in the US film industry: external economies, the division of labour, and the crossing of industrial divides, Cambridge Journal of Economics 13, 273-305

Storper, Michael and Allen J. Scott (1990), Work organisation and local labour markets in an era of flexible production, International Labour Review 129, 573-591

Appendix

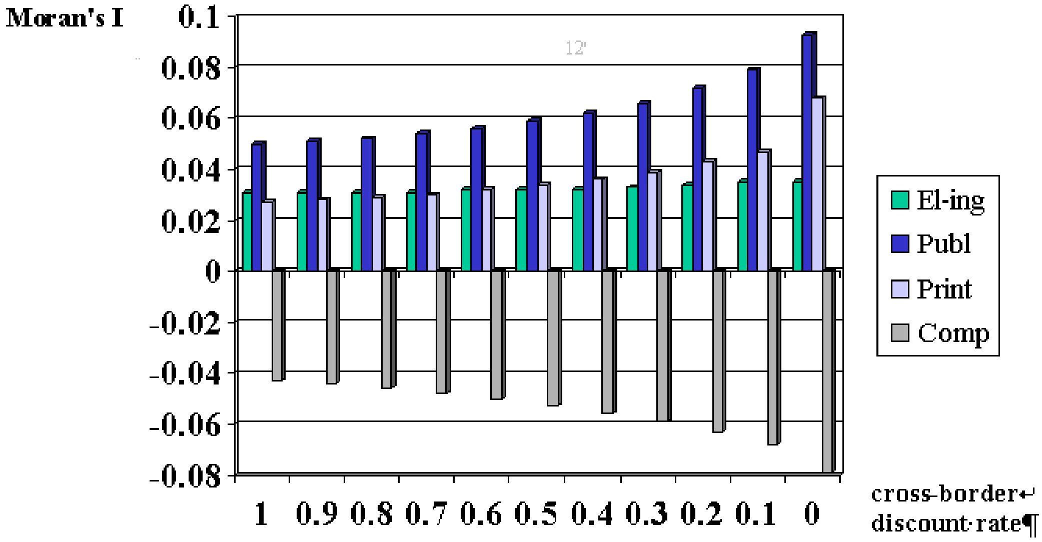


Figure A-1: Moran's I increasing with the cross-border discount rate for electrical engineers, publicists, computer personnel and printers

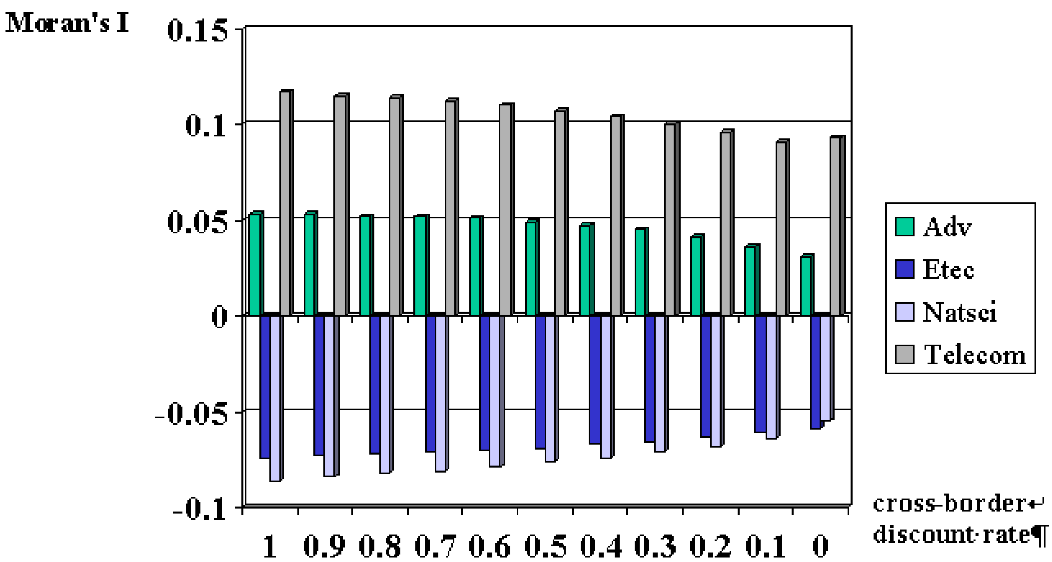


Figure A-2: Moran's I decreasing with the cross-border discount rate for electrical engineering technicians, natural scientists, telecommunication personnel and advertising personnel