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REGIONAL IMPACT ANALYSIS – MAIN DETERMINANTS OF AUSTRIAN, GERMAN AND SWISS REGIONS' COMPETITIVENESS

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Abstract
By common sense reasoning, it can be expected that regions' economic performance heavily relies on their endowment with modern infrastructure. The regional impact analysis, as applied in the paper at hand aims to show the relative importance of different types of infrastructure for the regions' competitiveness. Since the importance of transport infrastructure, modern telecommunication and institutional education might differ for different types of regions, a cluster analysis is performed in the first step. In doing so, Austrian, German and Swiss NUTS 3 regions are clustered into four types of regions (metropolitan, industrial, agricultural and tourist) by making use of cluster analysis methods based on different types of land cover data. In a second step the importance of the diverse types of infrastructure is identified for each cluster. This in turn, allows for a bottleneck analysis and the identification of the regions' performance in comparison to the other regions of the same cluster.

Content

1. INTRODUCTION

Following the neo-classical approach, capital, employment (measured in efficiency units) and technological changes can be considered the main determinants of economic growth (Solow 1970, Lucas 1988). Following this approach, the regions' competitiveness heavily depends on their success to attract private capital and qualified labour. But while the majority of regional decision-makers would certainly acknowledge the importance of these factors, success to attract these factors strongly differs.

In case of failure, public infrastructure investments are often considered the deus ex machina to overcome economic weaknesses and to return to the path of economic growth. But although infrastructural provisions are indeed critical success factors for regional competition, particularly if they enclose investments in transport, communication and educational infrastructure, there is a need for critical reflection (Nijkamp 1998).

The study at hand aims to analyse to which extend the regions' endowment with existing infrastructure hampers the success to attract private capital. If infrastructure turns out to limit regional competition, policy should clearly aim to alleviate this bottleneck. However, if regional competitiveness is low despite sufficient endowment of infrastructure, policies should obviously focus on other issues since opportunity costs of additional infrastructure investments would be too high.

Against this background, the paper intends to analyse the conditions under which infrastructure investments might generate the desired effect on the competitiveness of Austrian, German and Swiss regions.

2. APPROACHES TO MEASURE REGIONAL IMPACTS OF INFRASTRUCTURE

Methodologies to measure regional impacts of infrastructure investments can be subdivided into microscopic, macroscopic and mesoscopic approaches.

Microscopic approaches are based either on field studies exploring the effects of infrastructure investments of the past („ex-post assessment") or

project-related regional impact studies which try to identify the influences on locations, firms' production technologies and settlements.

Regional studies on actual and proven changes of producer's and consumer's behaviour have been performed for instance for the Great Belt project in Denmark or the Channel tunnel project between the UK and France. In both cases the results were modest so that Vickerman gives a clear warning to invest too much hope into the positive economic impacts of transport investments for the regions directly affected: "There are no compelling reasons for believing that the Channel Tunnel project will create an economic bonanza for the adjoining regions. If anything, there is some evidence that benefits are more likely to accrue to locations at some distance from the tunnel itself, say 100 to 150 km" (Vickerman, 1987). The World Bank (1994) concludes from a study on ex-post cost benefit assessment that in general two conditions are necessary (not sufficient) to generate boosting effects of infrastructure investments in adjoining regions:

- Severe bottleneck situation: Missing infrastructure links hamper economic activities and prevent the regional product from reaching the optimal level.
- Combination of infrastructure investments and massive regional structural support: If industries are attracted to regions lagging behind it is often necessary to combine development policies. Infrastructure may be an important part of the overall package to provide basic accessibility to modern transport and telecommunication networks. Furthermore, some industries might significantly benefit from research activities of nearby universities.

Macroscopic approaches usually start from time series of macroeconomic indicators and try to correlate them with data on infrastructure provision.[8] The most prominent example is the contribution of Aschauer (1989) that draws an extremely positive picture on the impacts of public capital provision like transport or telecommunication infrastructure. Inserting the public infrastructure as an explanatory variable into a macro-economic production function provides relatively high production elasticity for this factor. Public capital results in production elasticities between 0.38 and 0.56 in Aschauer's

[8] An overview about studies, which estimate the output elasticity of public infrastructure with production functions, is given by Pfähler (1995).

multiple regressions.[9] This implies a profitability of public capital between 100 and 150%.

Alternatively, cross section analysis can be applied and has been performed by Fritsch and Prud'homme (1997) for French regions. Within their research much lower production elasticities (0.085 – 0.100) are calculated. Growth effects could not be identified in terms of additional companies' enterprises, but very clearly the infrastructure investments had contributed to an increase in productivity (of labour and capital). This leads to a first important result: In general modern infrastructure contributes to a better use of existing resources. Whether this leads to an extension of production activity or higher employment is influenced by further factors.

The estimations of Fritsch and Prud'homme have been accomplished for 20 regions in France, which can be interpreted as a first step towards a deeper regional classification. Other studies go to the NUTS 2 levels or even below and try to include typical characteristics such as immobile and non-reproducible factors in the analysis. A typical mesoscopic approach is the potential factor analysis, which was introduced by Biehl et al. (1975) and extended in Biehl (1991). The methodology makes use of a quasi production function, usually of the Cobb-Douglas type (Rothengatter and Schaffer 2006):

(1) $GRP = f(PF_1, \ldots, PF_n)$

GRP: Gross regional product, in real terms,
PF_i: regional potential factor i.

PF_i is not a production factor comparable to labour or capital but rather measures the endowment with a certain immobile or non-reproducible resource of a region. If these properties are defined for the medium run, the potential factors will include natural resources, public capital, socio-demographic and soft factors.

Estimating the parameters of quasi-production function (1) on the base of cross section data results in an overall figure of the relative importance of the potential factors. By matching the results of the general estimation with the

[9] Production elasticity means that the output (e.g. gross domestic or gross regional product) will increase by 0.38% – 0.56%, if the input of transport infrastructure is increased by 1%.

regional specificities, measures of regional performance and of bottleneck situations with regard to particular potential factors can be derived. This permits to draw conclusions of the affinity of a region, incorporating the investment of public capital, and to estimate the effectiveness of infrastructure investment for the economic prospects of a region.

The philosophy behind potential factor modelling is, that a typical pattern of potential factors might attract a corresponding typical pattern of mobile capital or generate a corresponding pattern of labour input. The fact, that the interrelationships between potential factors can be captured by an appropriate construction of the quasi-production functions, is regarded as an advantage of potential factor modelling compared with macroscopic approaches.

3. A POTENTIAL FACTOR ANALYSIS FOR AUSTRIAN, GERMAN AND SWISS REGIONS

It can be assumed that potential factors like access to universities, education, centrality, transport infrastructure or telecommunication networks consist of varying parameter values for different types of regions. Therefore, the first step of the analysis clusters the considered Austrian, German and Swiss NUTS3-regions according to land use data.[10]

3.1 Regional cluster analysis

The regional classification is based on the following categories: a) percentage of settlement area, b) percentage of agricultural area and c) percentage of forest and unproductive area.

Settlement areas include artificial surfaces like housing and industrial areas, dumpsites, green urban areas or sports facilities. Agricultural area covers agricultural cropland, winegrowing area, area of fruit growing as well as grasslands and pastures. Finally, forest or unproductive area is consisting of two sub-attributes. Forest area comprises forests as well as bush and ground vegetation. Unproductive areas enclose open space with little or no vegeta-

[10] Sources are for Austria and Germany CORINE landcover 2000 and for Switzerland Arealstatistik Schweiz 2005

tion like areas with rocks, glaciers or beaches as well as wetlands and water bodies.

The cluster analysis is based on a hierarchical agglomerative classification method (Ward, 1963; Bergs, 1981; Backhaus 2006). According to this approach the number of clusters, which equals the number of regions at the beginning, is decreased step by step. The method is formally concluded at the point, when all regions belong to one single cluster. However, the process can be stopped earlier, if a certain level of heterogeneity, defined as sum of squared deviations, is not exceeded. In a cluster G with g regions the sum of squared deviations regarding three attributes amounts to:

$$AQS(G) = \sum_{k=1}^{g} \left(\sum_{j=1}^{3} (x_{kj} - \bar{x}_j)^2 \right) \quad (2)$$

AQS (G): sum of squared deviations of cluster G

x_{kj} : parameter value j of object k

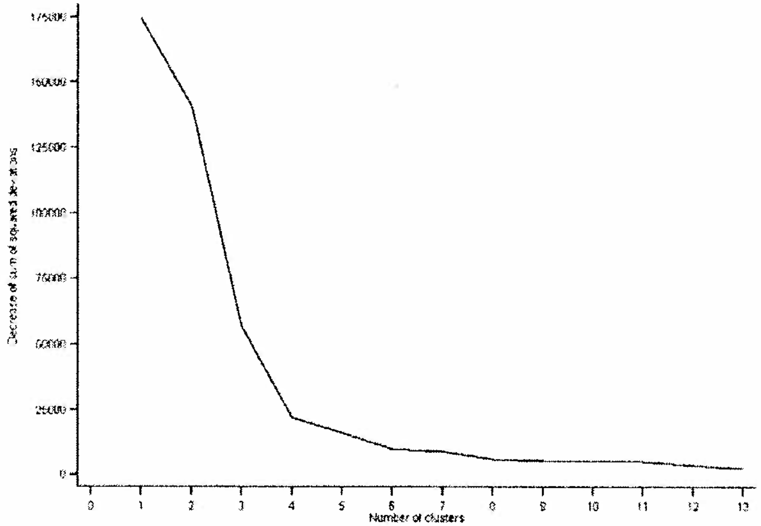
$\bar{x}_j$: mean of attribute j within all objects in G.

According to the so-called elbow criterion the number of clusters should be chosen in a way that the level of heterogeneity, measured in terms of the sum of squared deviations, would only decrease slightly if the number of cluster were increased. Considering the corresponding graphics, the largest kink, the so-called "elbow", points out the appropriate number of clusters (Aldenderfer and Blashfield 1984).

The elbow criterion (figure 1) suggests defining four clusters. In fact, the variance for any category within each cluster is smaller than the corresponding variance for all regions (table 1). This in turn confirms the adequacy of the classification into four regional groups.

In order to check whether the computed four clusters are a suitable basic solution for the potential factor analysis, the number of observations within a cluster should be reasonably high. This is the case, since none of the four clusters consists of less than 80 regions.

Figure 1: Illustration of elbow criterion for appropriate number of regional clusters



Source: own calculations

Table 1: Variance by regional cluster and land use categories

	Variance concerning *Percentage of settlement area*	Variance concerning *Percentage of agricultural area*	Variance concerning *Percentage of forest and unproductive area*	Reporting: Number of regions
All regions	245.6	366.3	358.4	500
Cluster 1	17.7	23.1	34.0	138
Cluster 2	32.3	54.2	62.7	157
Cluster 3	74.3	117.8	184.0	122
Cluster 4	173.1	158.2	76.5	83

Source: own calculations

Cluster 4 is characterised by comparatively high percentage of settlement area and particularly encloses regions with high population density. Thus, the cluster is labelled Metropolitan Regions. Cluster 1, named Industrial Core, shows a significant percentage of industrial area but in contrast to cluster 4 the percentage of the settlement area as a whole and the population density is smaller. Regions that belong to cluster 2 show rather low population density and particularly high percentage of agricultural area. Therefore, the cluster is called the Agricultural Core. Finally, cluster 3 encloses regions that do not belong to any of the other clusters. The percentage of settlement area is clearly below the percentage of metropolitan but above the percentage of rural areas. Contrary, share of agricultural area is smaller compared to rural regions but generally higher compared to the Industrial Core. In fact, the percentage of forest, water and mountain areas are comparatively high which in turn can be considered a tourism friendly endowment. Hence, the cluster is labelled Tourist and Rural Regions.

In principle, the procedure of clustering can be illustrated by dendrograms. However, due to the large number of regions, the graphic could hardly provide a clear overview. Instead of this, figure 2 gives a first survey on the results of the clustering.

The assignment of regions is the result of the described hierarchical agglomerative classification method based on the percentage of the described land use categories. According to the elbow criterion the process terminates at four clusters. Clusters are named according to only one chosen characteristic. As a consequence thereof some of the regions might not appear in the expected cluster. For example the region around Bern, the capital of Switzerland: While the city itself clearly belongs to the metropolitan regions, the corresponding NUTS 3 region includes quite some hinterland regions. Thus, the region is assigned to the tourist and rural regions. The same holds for the classification of Swiss agricultural regions. In fact, none is assigned to the agricultural core. However, this does not mean that agriculture is less relevant for Switzerland compared to Austria and Germany, but rather points to the fact that agriculture can be observed in regions that, due to their high percentage of forest and unproductive area, belong to the so-called cluster of tourist and rural regions rather than the agricultural core.

On the one hand, additional data, e.g. on the share of agricultural GVA, could indeed add important information to the clustering. On the other hand,

the above-described approach ensures a high level of transparency and defines a clear starting line for the potential factor analysis.

3.2 Potential factors

The GRP is often explained by a Cobb-Douglas type production function that in general refers to classic production factors such as private capital and labour inputs. Alternatively the GRP can also be explained by the so-called potential production factors, which are characterised by a high degree of public provision, polyvalence and immobility (Biehl 1991).

These factors do not only influence the current regional income, they also determine the potential wealth of the considered region. If the GRP is explained by the potential production factors, a quasi-production function can be set up. Equation (3) shows a quasi-production function of Cobb-Douglas type.

$$GRP = c \cdot PF_1^{\alpha_1} \cdot \ldots \cdot PF_n^{\alpha_n} \quad (3)$$

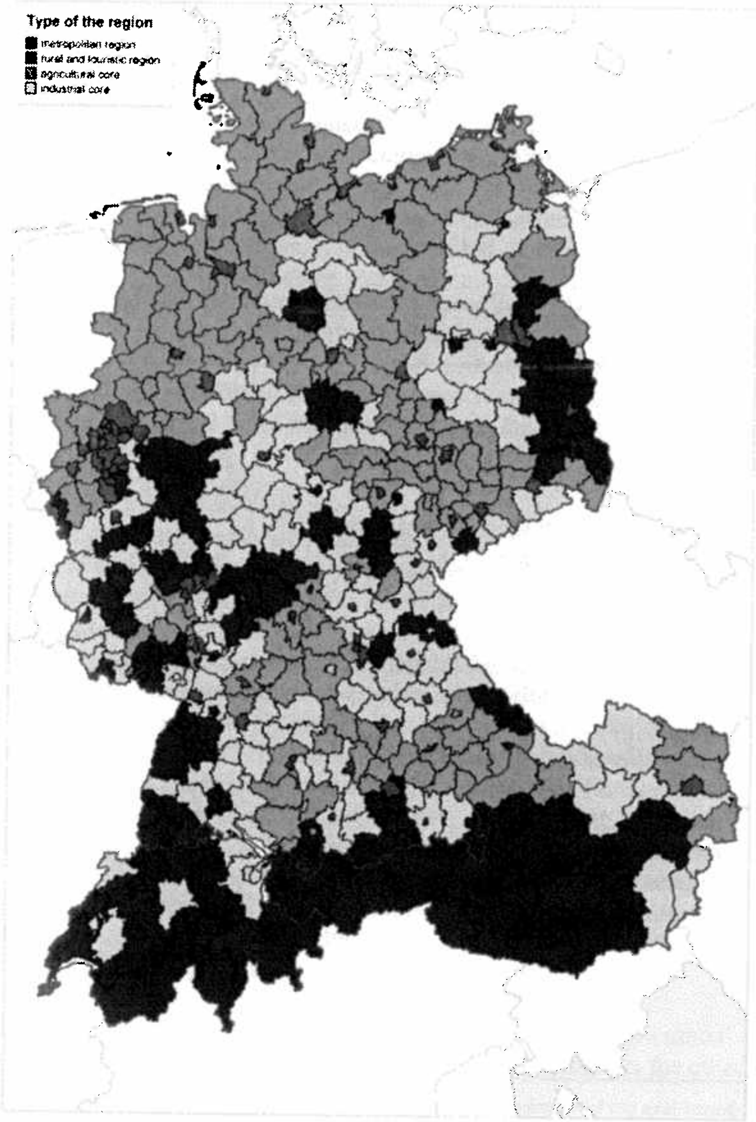
GRP: Gross Regional Product, in real terms,
PF_i: regional potential factor i,
α_i: elasticity of PF_i.

The following determinants fulfil main characteristics of potential factors and are considered as particularly important for the regions' competitiveness[11]:

1) Accessibility of universities (U),
2) Educational achievements (E),
3) Centrality (C),
4) Transport infrastructure, spatial component (IA),
5) Transport infrastructure, utilisation component (IP),
6) Telecommunication networks (T).

[11] Other determinants can be regarded important as a matter of course, e.g. the number of patent applications per region (Kramar 2005)

Figure 2: Regional cluster of Austrian, German and Swiss regions (NUTS 3)



1) Accessibility of universities

Economic impacts of educational infrastructure result, on the one hand, from the increase of educational achievements. Since alumni often leave their place of study, their knowledge is widely spread and any region might benefit from a functioning educational system (see 2)).

On the other hand, research activities of universities could very well stimulate settlement of knowledge-based industries, which in turn would encourage the economic performance of the surrounding regions. Therefore, the access to universities is considered an important potential factor. The corresponding indicator U is defined in the following way:

U = 180 minutes – average accessibility of nearest three universities in minutes

2) Level of education

Educational achievements of the regions' workforce are considered to define the regions' human capital. In this context, the International Standard Classification of Education (ISCED) enables the definition of three general levels of education: primary, secondary and tertiary qualification levels. ISCED 1 and 2 comprise persons aged 15 and older without professional degree (primary level). Persons who finished their apprenticeship belong to ISCED groups 3A, 3B or 4, which reflect the secondary level of education. Finally ISCED groups 5A (university degree), 5B (technical schools) and 6 (doctorate) account for persons with tertiary qualification.

A high level of education can be seen as key indicator for a region's competitiveness. Therefore the share of the work force with tertiary education defines the second quasi-production factor:

$$E = \frac{\text{persons aged 15 and older with high degrees (>ISCED 4)}}{\text{total number of persons aged 15 and older}}$$

3) Centrality

The centrality of a region is considered as the third quasi-production factor. The congruent indicator focuses on a region's connectivity with other regions. Thus the travel time between the considered eligible region and any other regions (eligible and non-eligible) mainly determines centrality C.

(4) $$C_i = \sum_j Pop_j \cdot e^{\omega \cdot \min(t_{rail}(i,j), t_{road}(i,j))}, i \neq j$$

Pop_j: Number of inhabitants in region j
t_{rail}: passenger transport time between region i and j by rail
t_{road}: passenger transport time between region i and j by road

The chosen parameter ω is a weighting factor that fulfils condition (5):

(5) $$e^{\omega \cdot T} = 0.5$$

T is set to 180 min, so that the population reached within that time is weighted by 0.5. Smaller weights are attributed to the population further away and higher weights account for the population that can be reached faster.

4) and 5) Transport infrastructure

At first transport infrastructure seems to be similar to centrality. But in contrast to centrality the focus here is on the intra-regional equipment with transport infrastructure. The regional road network is chosen as the main reference. The different quality of the roads are taken into account by different weighting factors. Motorways are weighted by factor 3, national routes by 2 and other roads by 1. Additionally the density of the network and the potential utilisation is considered. Therefore, the transport infrastructure indicator is split up into one spatial component IA and one utilisation component IP.

(6) $$IA = \frac{roadnetwork_{weighted}}{area}$$

(7) $$IP = \frac{population}{roadnetwork_{weighted}}$$

6) Telecommunication networks

Besides the physical mobility, virtual connectivity plays an even more important role for the population. This holds for people at work, but is also true for private households. In this context, internet access can be

considered as the key indicator. The quasi-production factor reflecting communication is defined as follows:

(8) $$T = \frac{\text{number of households with internet access}}{\text{total number of households}}$$

Since information on the type of access (DSL, analogue) is not available at NUTS 3 level, qualitative aspects cannot be included in this case.

3.3 Quasi-production function

After the definition of the potential factors, the quasi-production function can be set up. With regard to equation (3) the function is derived as follows:[12]

(9) $$GRP = c \cdot U^{\alpha_1} \cdot E^{\alpha_2} \cdot C^{\alpha_3} \cdot IA^{\alpha_4} \cdot IP^{\alpha_5} \cdot T^{\alpha_6}$$

GRP: Gross Regional Product per capita

To receive a linear connectivity, equation (9) is logarithmised:

(10) $$\begin{aligned} \ln GRP &= \ln c + \alpha_1 \cdot \ln U + \alpha_2 \cdot \ln E + \alpha_3 \cdot \ln C \\ &+ \alpha_4 \cdot \ln IA + \alpha_5 \cdot \ln IP + \alpha_6 \cdot \ln T \end{aligned}$$

By standardising the variables in equation (10) the new term (11) shows the connectivity between the applied potential factors U, E, C, IA, IP and T:[13]

(11) $$\begin{aligned} z\ln GRP &= \alpha_1 \cdot z\ln U + \alpha_2 \cdot z\ln E + \alpha_3 \cdot z\ln C \\ &+ \alpha_4 \cdot z\ln IA + \alpha_5 \cdot z\ln IP + \alpha_6 \cdot z\ln T \end{aligned}$$

The applied procedure of multiple linear regressions (on all regions) produces for these exogenous variables the following coefficients:

$\alpha_1 = -0.19, \quad \alpha_2 = 0.28, \quad \alpha_3 = -0.09, \quad \alpha_4 = 0.38, \quad \alpha_5 = 0.21, \quad \alpha_6 = 0.61$

[12] While creating a production function based on the regional potential factors, it is assumed, that the already mentioned attractable factors are combined with input potentials in fixed proportions (Kowalski, 2002).

[13] Detailed information on the process of standardisation is given by Bortz (2006, 44ff).

The negative coefficients α_1 and α_2 seem paradoxical, since a single linear regression between $z \ln U$ and $z \ln Y$ produces the positive correlation coefficient $\beta_1 = 0.24$ and a single linear regression between $z \ln C$ and $z \ln Y$ produces the positive correlation coefficient $\beta_2 = 0.17$.[14]

This effect points to a problem of collinearity between exogenous variables. Hence it makes sense to perform a factor analysis in order to replace all exogenous variables through factors, which are independent of each other (Backhaus et al., 2006; Bortz, 2006; Siegele, 2004).

According to the "Principal Component Analysis", which is a special procedure of factor analysis (Bortz 2006, 524ff), the multiple regression analysis is limited to four explanatory variables. These independent factors can, in the following, be explicitly identified by the Varimax-rotation approach (Bortz, 2006, 547ff; Kaiser 1958). For the presented study University Access and Centrality are combined to factor f_1. The level of education, telecommunication networks and road infrastructure defines factors f_2, f_3 and f_4 respectively. Finally, the application of the approach outlined by equations (9) to (11) results in the following setup:

$$z \ln GRP = \phi_1 \cdot z \ln f_1 + \phi_2 \cdot z \ln f_2 + \phi_3 \cdot z \ln f_3 + \phi_4 \cdot z \ln f_4$$

The application of the regression analysis leads to the following elasticities:

$\phi_1 = 0.07$, $\phi_2 = 0.33$, $\phi_3 = 0.43$, $\phi_4 = 0.17$

and the corresponding p-values:

$p_1 = 0.000$, $p_2 = 0.000$, $p_3 = 0.000$, $p_4 = 0.000$

The p-value is given as one of the most important statistical indicators. It shows the probability for accidental results. A p-value of 0.05, for example, means that the probability to receive the results for this variable by accident is less than 5%. Therefore low p-values point to a high significance of the results. The factor analysis ensures by definition a strong independence of the variables (which in turn leads to low p-values). The next step includes a

[14] As a precondition for the potential factors all six chosen potential factors contribute positively to the GRP.

cluster specific regression analysis, which is based on the four factors. Cluster specific elasticities permit a comparison between clusters.

Table 2: Elasticities of the regression analysis

		Cluster 1: Industrial core		Cluster 2: Agricultural core		Cluster 3: Rural and tourist regions		Cluster 4: Metropolitan Regions	
		Elasticity	p-value	Elasticity	p-value	Elasticity	p-value	Elasticity	p-value
Endogenous variable		GRP per capita							
Explaining factors (mainly represented by the potential factor(s))	f_1 (U(Access to universities) and C(Centrality))	0.09	0.042	0.06	0.139	0.07	0.070	0.08	0.433
	f_2 (E(Level of Education))	0.23	0.000	0.25	0.000	0.36	0.000	0.38	0.000
	f_3 (T(Telecommunication networks))	0.52	0.000	0.48	0.000	0.44	0.000	0.50	0.000
	f_4 (IP(Transport infrastructure)	0.15	0.001	0.21	0.000	0.12	0.002	0.04	0.741

Source: own calculations

The production elasticity gives a first idea about the relative importance of the corresponding production factor for the regions' competitiveness. Thus, the role of modern telecommunication can be considered particularly relevant for all clusters. In fact, it can be considered a pre-condition for the regions' potential economic development.

The same holds for educational achievements of the regions' employees. Not surprisingly, qualification levels are most important for metropolitan regions. But interestingly rural and tourist regions seem to have a strong need for highly educated persons. This can be explained by the cluster process, which is strictly based on land use data. As a consequence thereof some regions, such as the Austrian NUTS 3 region around Graz or the Swiss cantons Zurich and Bern, belong to rural and tourist regions. However, these regions are economically driven by the cities of Graz, Bern and Zurich, which show similar characteristics to German metropolitan areas.

Road transport infrastructure is most relevant for the agricultural and industrial core. This can be explained by the comparatively strong need for transport activity that is connected with the production of agricultural and industrial goods.

Finally, accessibility of universities (part of f_1) is, due to spill over effects, of particular interest for modern industries. The same holds for the modern services sector. In this context, the relative elasticity in the case of metropolitan regions is surprisingly low. However, the rather high p-value indicates a low significance of this result, i.e. it cannot finally be decided for the cluster of metropolitan regions, if the variation of factor f_l in average represents an influencing variable on the GRP.[15]

4. BOTTLENECK ANALYSIS

Infrastructure investments are considered an important tool to foster the regions' economic performance. According to the quasi-production function in section 3.3, public endowment with high quality transport and telecommunication infrastructure indeed plays an important role for the economic development. However, despite the relative importance, further investments will only serve as an impulse for the regions' economic performance when investments alleviate bottlenecks. If, by contrast, available infrastructure was not used efficiently, additional investments might not affect the performance at all.

Consequently, in order to identify suitable policy measures, a bottleneck analysis has to be done. Therefore the quasi-production function is applied to all regions of the considered cluster. Now the potential GRP per capita of each region can be derived by the following relation (12):

$$(12) \qquad Y_{ik}^{pot} = c_i \cdot f_{1ik}^{\phi_{1,i}} \cdot f_{2ik}^{\phi_{2,i}} \cdot f_{3ik}^{\phi_{3,i}} \cdot f_{4ik}^{\phi_{4,i}}$$

Y_{ik}^{pot}: potential GRP per capita in region k of cluster i, with i =1,2,3,4

In a second step the potential GRP per capita (Y_{ik}^{pot}) is compared with the real GRP per capita (Y_{ik}) for each region. After the comparison the regions can be subdivided into three groups:

(i) Over-average performing regions ($Y_{ik} > Y_{ik}^{pot}$)

(ii) Under-average performing regions ($Y_{ik} < Y_{ik}^{pot}$)

(iii) Average performing regions ($Y_{ik} = Y_{ik}^{pot}$)

[15] The same holds for the metropolitan regions' endowment with road transport infrastructure.

Over-average performing regions, which are characterised by relative over-utilisation of their development potential, are relatively better equipped with mobile or private capital than with public resources. This implies that the costs of attracting and using private capital are lower in high performing regions than in low performing ones. In this case public investments should be focused on public inputs as mentioned above. A better endowment with public resources will result in higher growth rates of the regional product. However, these regions run the risk of growing beyond their optimal degree of agglomeration and of increasing their benefits at the cost of pollution and time loss.

Under-average performing regions lack adequate quantities and qualities of private capital and labour. First of all, policy makers should concentrate their efforts on attracting private capital. In the short run it may be helpful to subsidise private investors. Due to the already existing under-utilisation of public inputs it would not be helpful to increase expenditures for public resources. If there is a sufficient endowment of public resources, this strategy will succeed. But as long as the costs of attracting private capital are high because of a low potential productivity (a result of low resource endowment), this strategy will fail in the long term. In this case, as long-term strategy, public resources have to be improved.

Table 3: Number of over- and under-average performing regions for each cluster

	over-average performing regions	under-average performing regions	Reporting: Number of regions
Cluster 1: Industrial core	59	79	138
Cluster 2: Agricultural core	78	79	157
Cluster 3: Rural and tourist regions	59	63	122
Cluster 4: Metropolitan regions	44	39	83

Source: own calculations

For average performing regions, potential and real incomes are equal. This points to a sound development, which can be preserved if the current regional policy is continued. However, since such equilibrium can hardly be observed for a longer period, the bottleneck analysis focuses on the first two cases. Table 3 summarises the number of over-average and under-average performing regions for each cluster.

The type of region combined with its performing status is given for every one of the 500 analysed regions in the annex. It should be emphasised that under- and over-average performance hardly gives an idea of the regions absolute competitiveness but rather points to an under-average efficiency in utilisation of existing public endowment. For example Geneva or Vienna can be considered highly competitive regions in absolute terms. However, the results of the bottleneck analysis suggest that their economic performance is still below their potential.

5. CONCLUSION AND OUTLOOK

The paper at hand identifies the impacts of potential production factors for the regions' competitiveness. In so doing, transport and telecommunication infrastructure, access to universities and educational achievements of the regional workforce are taken into account as most important factors.

As a precondition for the analysis of regions' performance with a potential factor analysis it is important to define different clusters. The clustering approach, which applies Ward's hierarchical clustering method for all 500 analysed Austrian, German and Swiss regions, results in an appropriate number of four clusters. These four clusters are referred to as metropolitan regions, tourist and rural regions, agricultural core and industrial core. For further refinement of the results especially regarding the industrial core additionally the non-hierarchical k-means clustering method can be applied.

The regression analysis, which is performed for the determined clusters, confirms the positive impacts of the chosen regional indicators. Against this background, a factor analysis has been chosen for the aggregation of indicators to potential production factors in order to avoid dependencies between certain indicators. This leads to the potential production factors communication, qualification, transport infrastructure and centrality. The results point to a high relevance of communication and qualification for each cluster. Centrality, based on physical accessibility, is particularly important for industrial regions, but plays a minor role for agricultural regions. Transport infrastructure is clearly positively related to the economic performance for all types of regions. However, investments into transport infrastructure will be most efficient, if the lack of these indeed hampers further development.

Therefore, the study continues with a bottleneck analysis and identifies over-average and under-average performing regions. The results show, that the performance is independent of the regions' national affiliation.

It can be concluded that under-average performing regions generally suffer from the lack of private capital. Also start-up financing and other measures to attract mobile capital are, compared to infrastructure investments, of even higher relevance. This does not mean that infrastructure investments would automatically fail to initiate further growth, but it means that other regions of the same cluster with an equivalent infrastructure endowment are currently more successful. Thus, it might be more important to increase the efficiency of the existing infrastructure than to invest in new infrastructure.

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Annex

CLUSTER 1: INDUSTRIAL CORE

OVER-AVERAGE PERFORMING REGIONS

CODE	NAME	CODE	NAME
AT111	Mittelburgenland	DE80C	Müritz
AT224	Oststeiermark	DE80I	Uecker-Randow
CH054	Appenzell Innerrhoden	DE913	Wolfsburg, Kreisfreie Stadt
DE112	Böblingen	DE923	Hameln-Pyrmont
DE135	Rottweil	DE926	Holzminden
DE136	Schwarzwald-Baar-Kreis	DE938	Soltau-Fallingbostel
DE143	Zollernalbkreis	DE93A	Uelzen
DE149	Sigmaringen	DEB14	Bad Kreuznach
DE21M	Traunstein	DEB17	Mayen-Koblenz
DE233	Weiden i. d. OPf.,Kreisfreie Stadt	DEB19	Rhein-Hunsrück-Kreis
DE235	Cham	DEB1B	Westerwaldkreis
DE236	Neumarkt i. d. OPf.	DEB23	Bitburg-Prüm
DE239	Schwandorf	DEB24	Daun
DE24C	Lichtenfels	DEB33	Landau in der Pfalz, Kreisfreie Stadt
DE24D	Wunsiedel i. Fichtelgebirge	DEB3E	Germersheim
DE251	Ansbach, Kreisfreie Stadt	DEC02	Merzig-Wadern
DE25C	Weißenburg-Gunzenhausen	DEC03	Neunkirchen
DE266	Rhön-Grabfeld	DEC04	Saarlouis
DE267	Haßberge	DEC05	Saarpfalz-Kreis

DE274	Memmingen, Kreisfreie Stadt	DEC06	St. Wendel
DE278	Günzburg	DED14	Annaberg
DE27B	Ostallgäu	DED17	Vogtlandkreis
DE411	Frankfurt (Oder), Kreisfreie Stadt	DED29	Sächsische Schweiz
DE416	Ostprignitz-Ruppin	DED2A	Weißeritzkreis
DE425	Elbe-Elster	DEE12	Anhalt-Zerbst
DE42A	Teltow-Fläming	DEE16	Wittenberg
DE732	Fulda	DEE26	Sangerhausen
DE733	Hersfeld-Rotenburg	DEE35	Jerichower Land
DE736	Waldeck-Frankenberg	DEE38	Quedlinburg
DE80B	Mecklenburg-Strelitz		

CLUSTER 1: INDUSTRIAL CORE

UNDER-AVERAGE PERFORMING REGIONS

CODE	NAME	CODE	NAME
AT113	Südburgenland	DE25B	Roth
AT121	Mostviertel-Eisenwurzen	DE276	Augsburg, Landkreis
AT123	Sankt Pölten	DE279	Neu-Ulm
AT124	Waldviertel	DE414	Oberhavel
AT127	Wiener Umland/Südteil	DE426	Havelland
AT313	Mühlviertel	DE428	Potsdam-Mittelmark
CH022	Fribourg	DE715	Bergstraße
CH025	Jura	DE716	Darmstadt-Dieburg
CH053	Appenzell Ausserrhoden	DE717	Groß-Gerau
CH055	St. Gallen	DE71E	Wetteraukreis
CH057	Thurgau	DE721	Gießen, Landkreis
CH061	Luzern	DE723	Limburg-Weilburg
DE113	Esslingen	DE724	Marburg-Biedenkopf
DE114	Göppingen	DE725	Vogelsbergkreis
DE116	Rems-Murr-Kreis	DE734	Kassel, Landkreis
DE11C	Heidenheim	DE735	Schwalm-Eder-Kreis
DE11D	Ostalbkreis	DE737	Werra-Meißner-Kreis
DE123	Karlsruhe, Landkreis	DE914	Gifhorn
DE127	Neckar-Odenwald-Kreis	DE915	Göttingen
DE128	Rhein-Neckar-Kreis	DE918	Northeim
DE12B	Enzkreis	DE933	Harburg

DE133	Emmendingen	DE934	Lüchow-Dannenberg
DE138	Konstanz	DE935	Lüneburg, Landkreis
DE141	Reutlingen	DEA28	Euskirchen
DE142	Tübingen, Landkreis	DEA2A	Oberbergischer Kreis
DE147	Bodenseekreis	DEA2C	Rhein-Sieg-Kreis
DE218	Ebersberg	DEA45	Lippe
DE219	Eichstätt	DEA47	Paderborn
DE21E	Landsberg a. Lech	DEA56	Ennepe-Ruhr-Kreis
DE21K	Rosenheim, Landkreis	DEB25	Trier-Saarburg
DE21N	Weilheim-Schongau	DEB3H	Südliche Weinstraße
DE226	Kelheim	DED18	Mittlerer Erzgebirgskreis
DE234	Amberg-Sulzbach	DEG07	Nordhausen
DE238	Regensburg, Landkreis	DEG0C	Gotha
DE23A	Tirschenreuth	DEG0E	Hildburghausen
DE245	Bamberg, Landkreis	DEG0F	Ilm-Kreis
DE246	Bayreuth, Landkreis	DEG0J	Saale-Holzland-Kreis
DE248	Forchheim	DEG0K	Saale-Orla-Kreis
DE249	Hof, Landkreis	DEG0P	Wartburgkreis
DE257	Erlangen-Höchstadt		

CLUSTER 2: AGRICULTURAL CORE

OVER-AVERAGE PERFORMING REGIONS

CODE	NAME	CODE	NAME
AT112	Nordburgenland	DE949	Emsland
DE118	Heilbronn, Landkreis	DE94B	Grafschaft Bentheim
DE119	Hohenlohekreis	DE94F	Vechta
DE11A	Schwäbisch Hall	DE94G	Wesermarsch
DE11B	Main-Tauber-Kreis	DEA1D	Neuss
DE146	Biberach	DEA33	Münster, Kreisfreie Stadt
DE148	Ravensburg	DEA34	Borken
DE214	Altötting	DEA42	Gütersloh
DE21B	Freising	DEA43	Herford
DE21G	Mühldorf a. Inn	DEA46	Minden-Lübbecke
DE21I	Neuburg-Schrobenhausen	DEA5B	Soest
DE223	Straubing, Kreisfreie Stadt	DEB39	Worms, Kreisfreie Stadt
DE224	Deggendorf	DEB3A	Zweibrücken, Kreisfreie Stadt
DE22A	Rottal-Inn	DED15	Chemnitzer Land
DE22C	Dingolfing-Landau	DED16	Freiberg
DE247	Coburg, Landkreis	DED19	Mittweida
DE24B	Kulmbach	DED24	Bautzen
DE256	Ansbach, Landkreis	DED25	Meißen
DE25A	Neustadt a. d. Aisch-Bad Windsheim	DED27	Riesa-Großenhain
DE268	Kitzingen	DED32	Delitzsch

DE273	Kempten (Allgäu), Kreisfreie Stadt	DED33	Döbeln
DE27C	Unterallgäu	DED35	Muldentalkreis
DE27D	Donau-Ries	DED36	Torgau-Oschatz
DE417	Prignitz	DEE13	Bernburg
DE418	Uckermark	DEE14	Bitterfeld
DE807	Bad Doberan	DEE15	Köthen
DE808	Demmin	DEE22	Burgenlandkreis
DE809	Güstrow	DEE23	Mansfelder Land
DE80A	Ludwigslust	DEE24	Merseburg-Querfurt
DE80G	Parchim	DEE25	Saalkreis
DE80H	Rügen	DEE27	Weißenfels
DE912	Salzgitter, Kreisfreie Stadt	DEE32	Aschersleben-Staßfurt
DE922	Diepholz	DEE33	Bördekreis
DE927	Nienburg (Weser)	DEE34	Halberstadt
DE929	Region Hannover	DEE36	Ohrekreis
DE939	Stade	DEE37	Stendal
DE93B	Verden	DEE39	Schönebeck
DE942	Emden, Kreisfreie Stadt	DEE3B	Altmarkkreis Salzwedel
DE948	Cloppenburg	DEG01	Erfurt, Kreisfreie Stadt

CLUSTER 2: AGRICULTURAL CORE

UNDER-AVERAGE PERFORMING REGIONS

CODE	NAME	CODE	NAME
AT125	Weinviertel	DEA1F	Wesel
AT126	Wiener Umland/Nordteil	DEA26	Düren
AT311	Innviertel	DEA27	Erftkreis
AT312	Linz-Wels	DEA29	Heinsberg
DE115	Ludwigsburg	DEA35	Coesfeld
DE145	Alb-Donau-Kreis	DEA37	Steinfurt
DE217	Dachau	DEA38	Warendorf
DE21A	Erding	DEA44	Höxter
DE21C	Fürstenfeldbruck	DEA54	Hamm, Kreisfreie Stadt
DE21J	Pfaffenhofen a. d. Ilm	DEA5C	Unna
DE227	Landshut, Landkreis	DEB31	Frankenthal (Pfalz), Kreisfreie Stadt
DE228	Passau, Landkreis	DEB3B	Alzey-Worms
DE22B	Straubing-Bogen	DEB3D	Donnersbergkreis
DE258	Fürth, Landkreis	DEB3G	Kusel
DE26B	Schweinfurt, Landkreis	DEB3I	Ludwigshafen, Landkreis
DE26C	Würzburg, Landkreis	DEB3J	Mainz-Bingen
DE275	Aichach-Friedberg	DED1A	Stollberg
DE277	Dillingen a.d. Donau	DED1C	Zwickauer Land
DE27A	Lindau (Bodensee)	DED28	Löbau-Zittau
DE413	Märkisch-Oderland	DED34	Leipziger Land

DE80D	Nordvorpommern	DEF05	Dithmarschen
DE80E	Nordwestmecklenburg	DEF06	Herzogtum Lauenburg
DE80F	Ostvorpommern	DEF07	Nordfriesland
DE917	Helmstedt	DEF08	Ostholstein
DE91A	Peine	DEF09	Pinneberg
DE91B	Wolfenbüttel	DEF0A	Plön
DE925	Hildesheim	DEF0B	Rendsburg-Eckernförde
DE928	Schaumburg	DEF0C	Schleswig-Flensburg
DE932	Cuxhaven	DEF0D	Segeberg
DE936	Osterholz	DEF0E	Steinburg
DE937	Rotenburg (Wümme)	DEF0F	Stormarn
DE946	Ammerland	DEG02	Gera, Kreisfreie Stadt
DE947	Aurich	DEG06	Eichsfeld
DE94A	Friesland	DEG09	Unstrut-Hainich-Kreis
DE94C	Leer	DEG0A	Kyffhäuserkreis
DE94D	Oldenburg, Landkreis	DEG0D	Sömmerda
DE94E	Osnabrück, Landkreis	DEG0G	Weimarer Land
DE94H	Wittmund	DEG0L	Greiz
DEA1B	Kleve	DEG0M	Altenburger Land
DEA1E	Viersen		

CLUSTER 3: RURAL AND TOURISTIC REGIONS

OVER-AVERAGE PERFORMING REGIONS

CODE	NAME	CODE	NAME
AT211	Klagenfurt-Villach	DE269	Miltenberg
AT212	Oberkärnten	DE26A	Main-Spessart
AT213	Unterkärnten	DE27E	Oberallgäu
AT222	Liezen	DE423	Potsdam, Kreisfreie Stadt
AT223	Östliche Obersteiermark	DE711	Darmstadt, Kreisfreie Stadt
AT225	West- und Südsteiermark	DE718	Hochtaunuskreis
AT226	Westliche Obersteiermark	DE802	Neubrandenburg, Kreisfreie Stadt
AT314	Steyr-Kirchdorf	DE804	Schwerin, Kreisfreie Stadt
AT322	Pinzgau-Pongau	DE919	Osterode am Harz
AT331	Außerfern	DE931	Celle
AT334	Tiroler Oberland	DEA57	Hochsauerlandkreis
AT335	Tiroler Unterland	DEA58	Märkischer Kreis
AT341	Bludenz-Bregenzer Wald	DEA59	Olpe
CH051	Glarus	DEA5A	Siegen-Wittgenstein
CH056	Graubünden	DEB11	Koblenz, Kreisfreie Stadt
CH062	Uri	DEB13	Altenkirchen (Westerwald)
CH064	Obwalden	DEB15	Birkenfeld
CH07	Ticino	DEB16	Cochem-Zell
DE121	Baden-Baden, Stadtkreis	DEB18	Neuwied
DE124	Rastatt	DEB21	Trier, Kreisfreie Stadt

DE129	Pforzheim, Stadtkreis	DEB22	Bernkastel-Wittlich
DE12C	Freudenstadt	DEB32	Kaiserslautern, Kreisfreie Stadt
DE134	Ortenaukreis	DEB36	Neustadt an der Weinstraße, Kreisfreie Stadt
DE137	Tuttlingen	DEB37	Pirmasens, Kreisfreie Stadt
DE216	Bad Tölz-Wolfratshausen	DEC01	Stadtverband Saarbrücken
DE21H	München, Landkreis	DED2B	Kamenz
DE225	Freyung-Grafenau	DEE11	Dessau, Kreisfreie Stadt
DE229	Regen	DEE3A	Wernigerode
DE24A	Kronach	DEG0N	Eisenach, Kreisfreie Stadt
DE265	Bad Kissingen		

CLUSTER 3: RURAL AND TOURISTIC REGIONS

UNDER-AVERAGE PERFORMING REGIONS

CODE	NAME	CODE	NAME
AT122	Niederösterreich-Süd	DE259	Nürnberger Land
AT221	Graz	DE264	Aschaffenburg, Landkreis
AT315	Traunviertel	DE412	Barnim
AT321	Lungau	DE415	Oder-Spree
AT323	Salzburg und Umgebung	DE421	Brandenburg an der Havel, Kreisfreie Stadt
AT332	Innsbruck	DE424	Dahme-Spreewald
AT333	Osttirol	DE427	Oberspreewald-Lausitz
AT342	Rheintal-Bodenseegebiet	DE429	Spree-Neiße
CH011	Vaud	DE713	Offenbach am Main, Kreisfreie Stadt
CH012	Valais	DE719	Main-Kinzig-Kreis
CH021	Bern	DE71B	Odenwaldkreis
CH023	Solothurn	DE71C	Offenbach, Landkreis
CH024	Neuchâtel	DE71D	Rheingau-Taunus-Kreis
CH032	Basel-Landschaft	DE722	Lahn-Dill-Kreis
CH033	Aargau	DE916	Goslar
CH04	Zürich	DEA25	Aachen, Kreis
CH052	Schaffhausen	DEA2B	Rheinisch-Bergischer Kreis
CH063	Schwyz	DEA53	Hagen, Kreisfreie Stadt
CH065	Nidwalden	DEB12	Ahrweiler
CH066	Zug	DEB1A	Rhein-Lahn-Kreis

DE125	Heidelberg, Stadtkreis	DEB3C	Bad Dürkheim
DE12A	Calw	DEB3F	Kaiserslautern, Landkreis
DE131	Freiburg im Breisgau, Stadtkreis	DEB3K	Südwestpfalz
DE132	Breisgau-Hochschwarzwald	DED1B	Aue-Schwarzenberg
DE139	Lörrach	DED23	Hoyerswerda, Kreisfreie Stadt
DE13A	Waldshut	DED26	Niederschlesischer Oberlausitzkreis
DE215	Berchtesgadener Land	DEG03	Jena, Kreisfreie Stadt
DE21D	Garmisch-Partenkirchen	DEG04	Suhl, Kreisfreie Stadt
DE21F	Miesbach	DEG0B	Schmalkalden-Meiningen
DE21L	Starnberg	DEG0H	Sonneberg
DE222	Passau, Kreisfreie Stadt	DEG0I	Saalfeld-Rudolstadt
DE237	Neustadt a. d. Waldnaab		

CLUSTER 4: METROPOLITAN REGIONS

OVER-AVERAGE PERFORMING REGIONS

CODE	NAME	CODE	NAME
DE111	Stuttgart, Stadtkreis	DE501	Bremen, Kreisfreie Stadt
DE117	Heilbronn, Stadtkreis	DE502	Bremerhaven, Kreisfreie Stadt
DE122	Karlsruhe, Stadtkreis	DE712	Frankfurt am Main, Kreisfreie Stadt
DE126	Mannheim, Stadtkreis	DE714	Wiesbaden, Kreisfreie Stadt
DE144	Ulm, Stadtkreis	DE731	Kassel, Kreisfreie Stadt
DE211	Ingolstadt, Kreisfreie Stadt	DE801	Greifswald, Kreisfreie Stadt
DE212	München, Kreisfreie Stadt	DE803	Rostock, Kreisfreie Stadt
DE213	Rosenheim, Kreisfreie Stadt	DE805	Stralsund, Kreisfreie Stadt
DE221	Landshut, Kreisfreie Stadt	DE806	Wismar, Kreisfreie Stadt
DE231	Amberg, Kreisfreie Stadt	DE944	Osnabrück, Kreisfreie Stadt
DE232	Regensburg, Kreisfreie Stadt	DE945	Wilhelmshaven, Kreisfreie Stadt
DE241	Bamberg, Kreisfreie Stadt	DEA11	Düsseldorf, Kreisfreie Stadt
DE242	Bayreuth, Kreisfreie Stadt	DEA23	Köln, Kreisfreie Stadt
DE243	Coburg, Kreisfreie Stadt	DEB34	Ludwigshafen am Rhein, Kreisfreie Stadt
DE244	Hof, Kreisfreie Stadt	DEB35	Mainz, Kreisfreie Stadt
DE253	Fürth, Kreisfreie Stadt	DEB38	Speyer, Kreisfreie Stadt
DE261	Aschaffenburg, Kreisfreie Stadt	DED11	Chemnitz, Kreisfreie Stadt
DE262	Schweinfurt, Kreisfreie Stadt	DED13	Zwickau, Kreisfreie Stadt
DE263	Würzburg, Kreisfreie Stadt	DED21	Dresden, Kreisfreie Stadt
DE271	Augsburg, Kreisfreie Stadt	DED31	Leipzig, Kreisfreie Stadt

DE272	Kaufbeuren, Kreisfreie Stadt	DEE21	Halle (Saale), Kreisfreie Stadt
DE422	Cottbus, Kreisfreie Stadt	DEE31	Magdeburg, Kreisfreie Stadt

CLUSTER 4: METROPOLITAN REGIONS

UNDER-AVERAGE PERFORMING REGIONS

CODE	NAME	CODE	NAME
AT130	Wien	DEA1A	Wuppertal, Kreisfreie Stadt
CH013	Genève	DEA1C	Mettmann
CH031	Basel-Stadt	DEA21	Aachen, Kreisfreie Stadt
DE252	Erlangen, Kreisfreie Stadt	DEA22	Bonn, Kreisfreie Stadt
DE254	Nürnberg, Kreisfreie Stadt	DEA24	Leverkusen, Kreisfreie Stadt
DE255	Schwabach, Kreisfreie Stadt	DEA31	Bottrop, Kreisfreie Stadt
DE300	Berlin	DEA32	Gelsenkirchen, Kreisfreie Stadt
DE600	Hamburg	DEA36	Recklinghausen
DE71A	Main-Taunus-Kreis	DEA41	Bielefeld, Kreisfreie Stadt
DE911	Braunschweig, Kreisfreie Stadt	DEA51	Bochum, Kreisfreie Stadt
DE941	Delmenhorst, Kreisfreie Stadt	DEA52	Dortmund, Kreisfreie Stadt
DE943	Oldenburg (Oldenburg), Kreisfreie Stadt	DEA55	Herne, Kreisfreie Stadt
DEA12	Duisburg, Kreisfreie Stadt	DED12	Plauen, Kreisfreie Stadt
DEA13	Essen, Kreisfreie Stadt	DED22	Görlitz, Kreisfreie Stadt
DEA14	Krefeld, Kreisfreie Stadt	DEF01	Flensburg, Kreisfreie Stadt
DEA15	Mönchengladbach, Kreisfreie Stadt	DEF02	Kiel, Kreisfreie Stadt
DEA16	Mülheim an der Ruhr, Kreisfreie Stadt	DEF03	Lübeck, Kreisfreie Stadt
DEA17	Oberhausen, Kreisfreie Stadt	DEF04	Neumünster, Kreisfreie Stadt
DEA18	Remscheid, Kreisfreie Stadt	DEG05	Weimar, Kreisfreie Stadt
DEA19	Solingen, Kreisfreie Stadt		