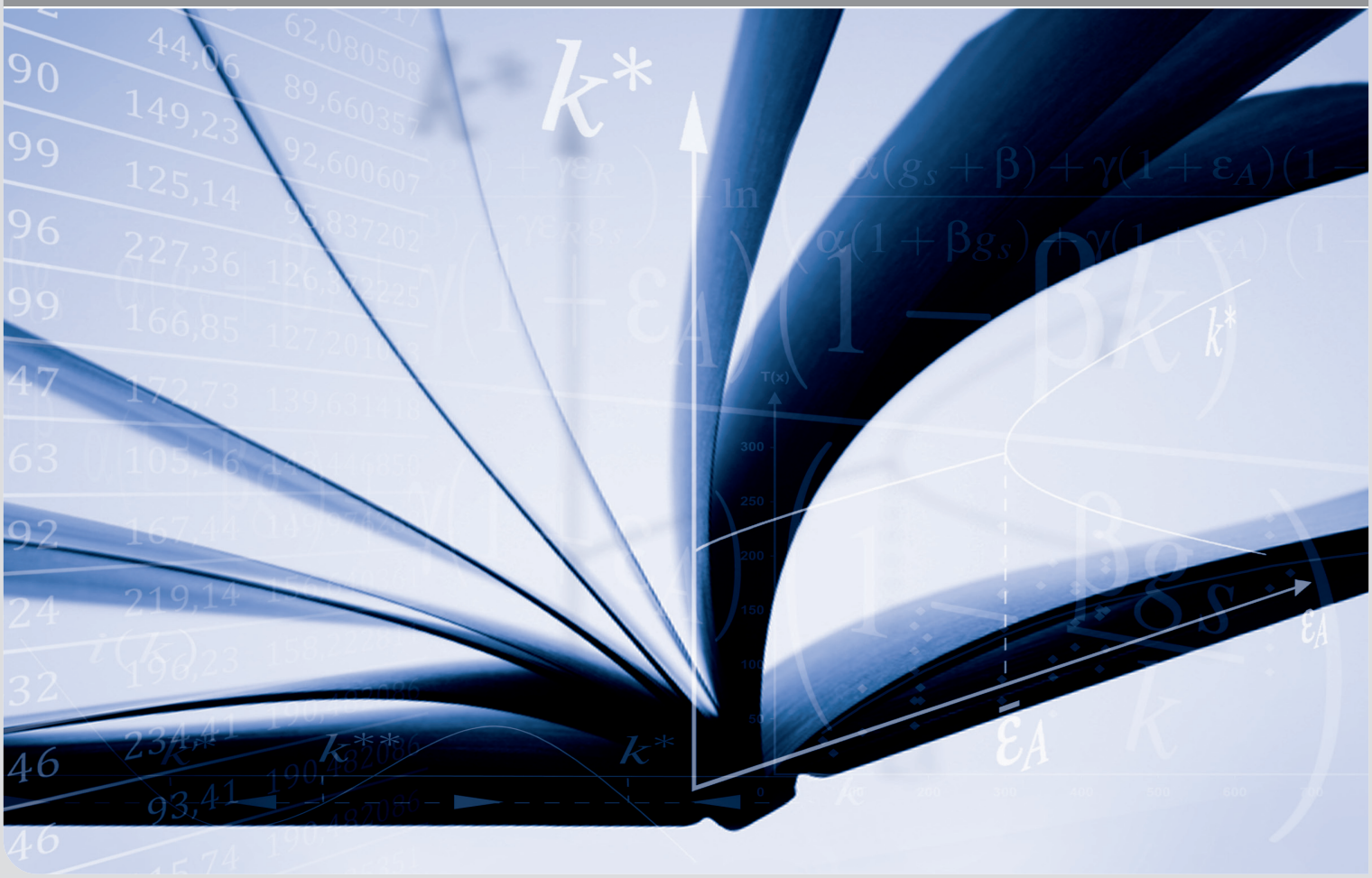
Karlsruher Institut für Technologie

Appropriate policy measures to attract private capital in consideration of regional efficiency in using infrastructure and human capital

by Axel Schaffer

No. 31 | JULY 2011

WORKING PAPER SERIES IN ECONOMICS



KIT – University of the State of Baden-Wuerttemberg and
National Laboratory of the Helmholtz Association

econpapers.wiwi.kit.edu

Impressum

Karlsruher Institut für Technologie (KIT)
Fakultät für Wirtschaftswissenschaften
Institut für Wirtschaftspolitik und Wirtschaftsforschung (IWW)
Institut für Wirtschaftstheorie und Statistik (ETS)

Schlossbezirk 12
76131 Karlsruhe

KIT – Universität des Landes Baden-Württemberg und
nationales Forschungszentrum in der Helmholtz-Gemeinschaft

Working Paper Series in Economics
No. 31, July 2011

ISSN 2190-9806

econpapers.wiwi.kit.edu

Appropriate policy measures to attract private capital in consideration of regional efficiency in using infrastructure and human capital

Axel Schaffer, Institut für Entwicklung zukunftsfähiger Organisationen, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577 Neubiberg, axel.schaffer@unibw.de *und* Institut für Wirtschaftspolitik und Wirtschaftsforschung, Karlsruher Institut für Technologie, Geb. 20.14, 76128 Karlsruhe, schaffer@kit.edu

Abstract: Regional economic policy disposes of two principal options to attract private capital, which in turn helps to safeguard employment and to foster regional growth. On the one hand, regional policy could seek to enhance a region's level of public capital (e.g. transport infrastructure), which as a consequence makes the region more attractive to private investors in general. On the other hand, private capital could be attracted in a more direct way by proposing specific innovation, SME or cluster programs.

The success of both options is partly driven by the regions already existing level of region specific production factors *and* the ability to use these factors efficiently. Indirect approaches to attract private capital seem to be particularly promising for efficient regions (no matter of the absolute level of public capital). In contrast, inefficient regions shall benefit more from specific programs. However, for Germany the factual pattern seems to be the other way around, which could widening rather than closing the income gap among regions.

1 Introduction

More than 15 years after the 2004 enlargement of the European Union, employment rate and per capita income are still significantly lower in East European regions. Hence, regional convergence has remained a key objective of EU regional policy which is worth €347 billion between 2007 and 2013. A substantial part of this amount goes to East-German regions which additionally benefit from national investment programs.

The diverse programs are targeted to attract private capital in comparatively disadvantaged regions which in turn helps to safeguard employment and to foster regional growth. In so doing, regional economic policy disposes of two principal options. On the one hand, policymakers could seek to enhance a region's level of polyvalent mostly immobile factors, which as a consequence makes the region more attractive to private investors in general. The majority of these *indirect* approaches promotes modern transport infrastructure and educational achievements of the regional workforce. On the other hand, private capital could

be attracted in a more *direct* way by proposing specific innovation, SME or cluster programs. The success of both options is driven by the regions already existing level of infrastructure and human capital *and* the ability to use these factors efficiently.

The presented paper follows this train of thought and aims to assign appropriate policy options to German Nuts 3 regions in dependence on their income and efficiency level. Indirect approaches can be considered particularly promising for relatively poor but comparatively efficient regions – efficient in terms of using the already existing infrastructure and human capital. In contrast, poor and inefficient regions' shall particularly benefit from specific programs to attract private capital more directly.

The paper is structured as follows. Section 2 gives a short summary on existing EU programs to foster growth and integration of German regions. The findings reflect the relevance of both direct and indirect approaches and confirm for the latter category the key role of infrastructure investments and the promotion of educational attainments. Section 3 identifies different regimes by taking into account the regions' income and efficiency level. For this purpose, efficiency is further decomposed into a smoothed spatial and a non-spatial, arguably structural component (Schaffer et al., 2011). Section 4 concludes with a discussion of appropriate use of indirect and direct approaches to enhance competitiveness of the regions in dependence on these regimes.

2 European Regional Policy for Germany 2007-2013

European regional policy aims to increase the competitiveness of European regions at a global level and to reduce existing economic and social disparities within the community. In order to finance the policy, three major funds have been established: the Cohesion Fund, the European Regional Development Fund (ERDF) and the European Social Fund (ESF).

For German regions, which are according EU rules not eligible for support from the Cohesion fund (between 2007 and 2013), the main interest is on programs (co-)funded from the ERDF or the ESF (EC, 2007). These programs are rich in variety and it would go beyond the scope of this study to draw a complete picture. Prior aim of this section is rather to give a first idea of priority axis and their rough classification into direct and indirect approaches.[1]

Most programs that apply to German regions are launched in cooperation with the federal States and total EU transfers easily exceed €23 billion – not counting several billions from cross-border programs such as *Alpine Space, INTERREG IV Upper Rhine* or *Baltic Sea*

[1] Due to Germany's economic importance, its location in the heart of Europe and the still existing East-West divide in terms of per-capita income, the German example might very well reflect the European situation as a whole.

Regions. Although the lion's share goes to the New German Laender programs are not at all limited to East Germany.[2]

Considering the ERDF, programs worth more than €14 billion (excl. cross-border programs) can be assigned to six priority axes:

1. *Urban and regional development*: Programs seek to improve economic, social or ecological development of comparatively disadvantaged urban and local areas by revitalization of fallow and conversion grounds, improvement of local transport systems and integrated urban development projects.
2. *Supraregional transport infrastructure*: Prior aim of programs under this priority is to improve the link of comparatively disadvantaged regions with important business locations. Investments seek to eliminate bottlenecks in road, rail and inland waterway and maritime infrastructure. The focus on environmentally friendly modes points to the Commissions efforts to foster the shift from road transport to environmentally more friendly modes.
3. *Improvement of education, training and research infrastructure*: Programs are targeted to improve the conditions of institutional education which in turn allows implementing innovative approaches in schools, (applied) universities, research and vocational training centers.
4. *Risk precaution, resource protection and the environment*: Natural catastrophes have become more frequent and their economic and social impacts more intense in recent years. In order to counter this development, regional policy has activated measures of flood and storm protection and against landslides and avalanches and programs to protect resources and preserve the environment.

Most investments that come along with the programs under priority axes 1 to 4 are characterized by a high degree of polyvalence, immobility and indivisibility. Thus, the activities aim to improve the regions' general attractiveness to investors and to attract private capital in an indirect way. In contrast, specificity of programs realized with the frame of priority axes 5 and 6 is much higher and most programs are targeted directly at potential investors.

5. *Industrial competitiveness*: Most of the programs seek to maintain regional competitiveness by financial support of SMEs and business start-ups. Instruments include, but are not limited to the provision of loans, venture capital, subsidies or the

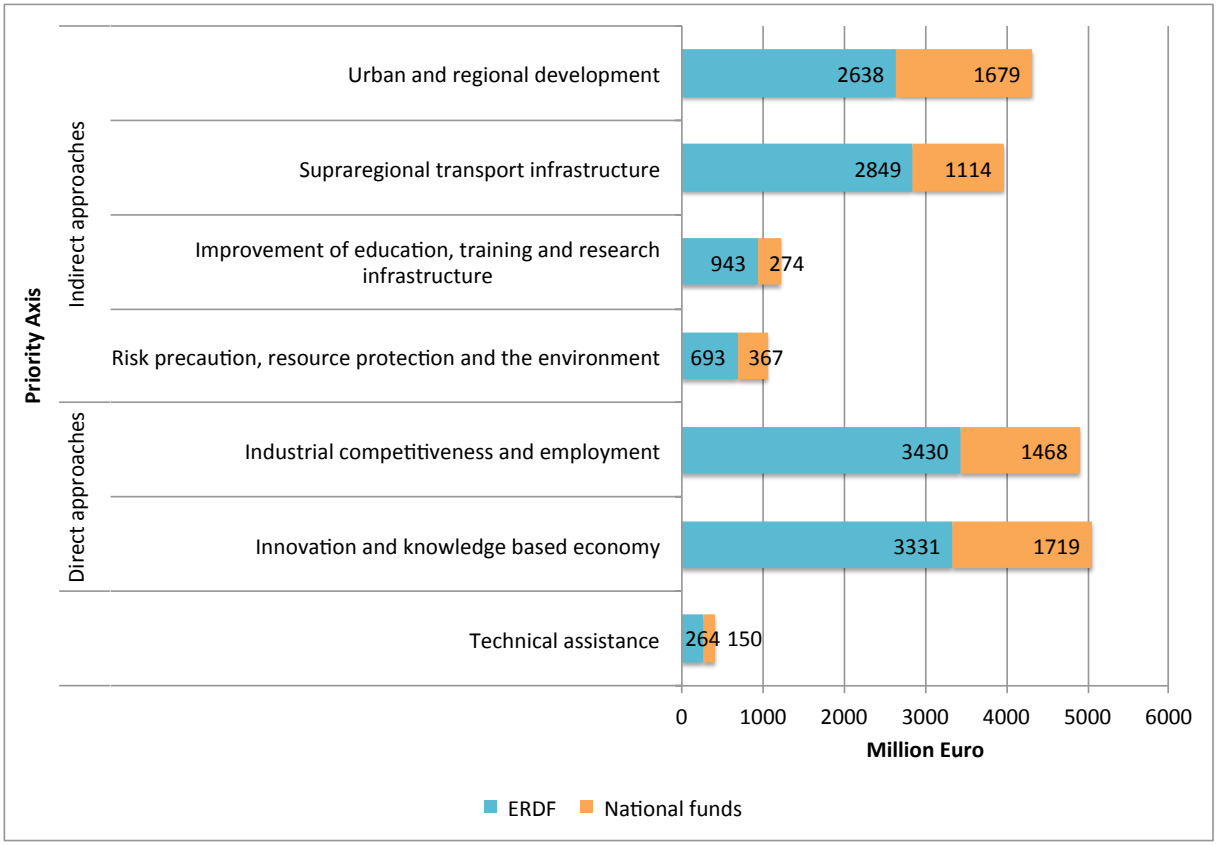
[2] About 60% of the considered funds go to East-German regions whose population share amounts to approximately 20%.

establishment of revolving funds. Integrated approaches often combine the financial support with the provision of technical and organizational advice.

6. *Innovation and knowledge based economy*: Following the Lisbon Strategy programs assigned to this priority axis aim to strengthen the innovative base of firms, by promoting R&D capabilities of individual firms or industrial clusters and close cooperation between science and industries. Thus, the programs are targeted at creating new knowledge and its transformation into marketable goods.

Figure 1 illustrates the financial frame of these axes. Since most programs are co-funded by the federal state or the national government, the total volume increases from about €14 billion to €21 billion.

Figure 1. ERDF programs for German Regions (excl. cross-border programs including national and federal co-funding), 2007-2013.



Source: European Commission (2011)

The differentiation of direct and indirect approaches should not be seen as irrevocable truth. Urban and regional development programs, for example, could indeed include branch- or even firm-specific projects with a rather low degree of polyvalence. At the same time,

programs targeted to accelerate the transformation to a knowledge-based economy often include the establishment of technology transfer centers, which in a sense could be considered part of the research infrastructure. However, despite these uncertainties the data suggest that both approaches play a crucial role for regional policy – with regard to the ERDF most likely of similar importance.
The budget for technical assistance pays for preparation and implementation of the programs as well as monitoring measures.

For the same period (2007-2013) German regions additionally benefit from the ESF. The programs, which focus on education and vocational training, can again be assigned to (mostly) indirect approaches (priority axes 1 to 3) and direct measures (priority axes 4 and 5) respectively.

1. *Employment and social integration*: The main purpose of the programs within this priority axis is to improve equal access to employment. Programs are targeted to balance work and family life and thus to increase women's participation rate and further seek to integrate disadvantaged people in a better way.
2. *Promotion of education and training*: Related activities aim to enhance professional qualification of active and potential employees. On the one hand, investments are directed to youngsters at the beginning of their career. On the other hand, programs are devoted to life long learning and support active ageing and longer work lives. Furthermore, activities aim to activate migrants' existing but often unused educational achievements.
3. *Reforming of education and training systems and infrastructure*: Programs under this priority set the stage for the successful implementation of new concepts such as life long learning. Investments seek to enhance the service capability of institutional education and training centers (e.g. by upgrading teaching quality, improving communication networks or modernizing computer systems) and promote the closer cooperation of business, science and education.
4. *Employment and training support for SME and new businesses*: Related programs have a higher specificity compared to the programs assigned to priority axes 1 to 3, since investments aim to secure competitiveness and employment of particular firms that have applied for funding. Key issues of these programs are the stabilization of start-ups and the safeguarding of jobs in medium-sized enterprises, which can be considered the backbone of the German economy.

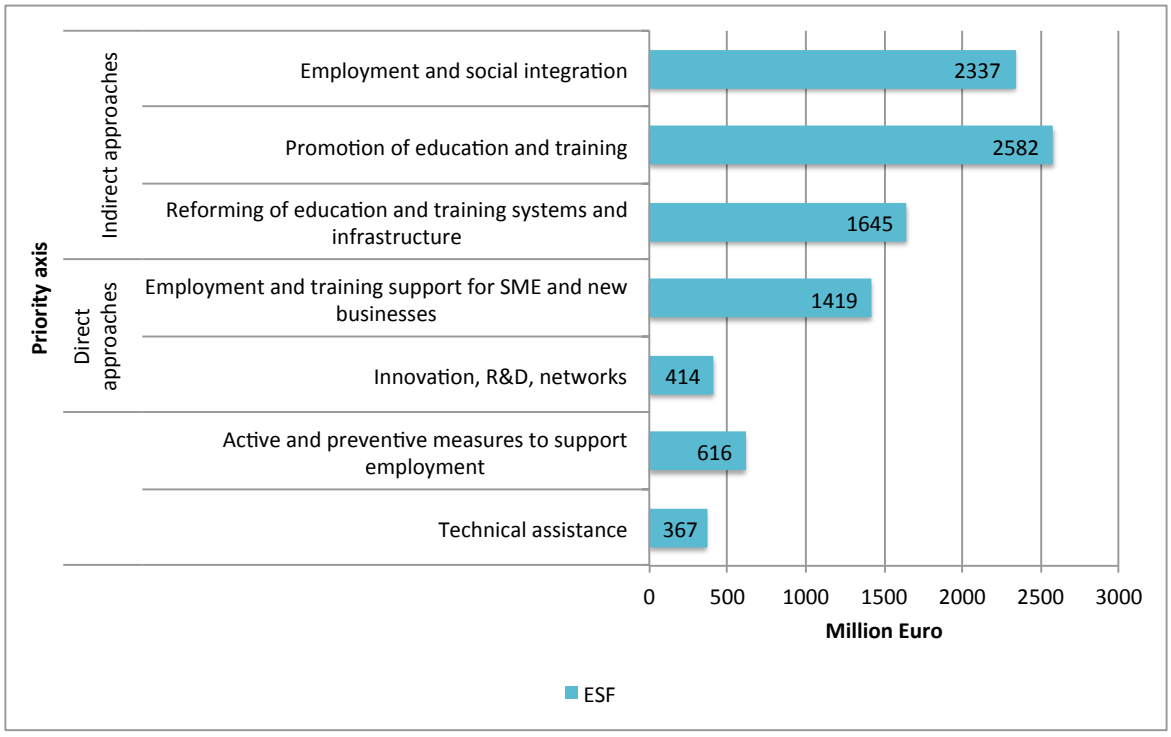
5. *Innovation, R&D, networks*: Initiatives within this priority axis intend develop firms' in-house research and development potential and to accelerate the distribution of process and organizational innovations. Thus, programs shall foster more productive ways of working. In addition firms are encouraged to cooperate with research centers and to build networks with other firms.

A broad mix of direct and indirect measures characterizes a sixth policy bundle. Hence, the priority axis as a whole can neither be categorized as direct nor indirect approach.

6. *Active and preventive measures to support employment*: Measures under this priority axis range from strengthening of knowledge transfer from universities to SME, via the establishment of career services at universities to early stage entrepreneurial education.

Figure 2 gives a brief overview on the axes' financial volume, which in total amounts to approximately €9.5 billion. Most programs are again co-funded from national or federal funds but unfortunately the clear assignment to the sixth priority axis was not possible. However, it can be assumed that EC's share ranges between 50% and 70%.

Figure 2. ESF programs for German Regions, 2007-2013.



Source: European Commission (2011), Die Bundesregierung (2011)

Although the figure might suggest a clear divide of direct and indirect approaches, again the differentiation rather points to the main justification of the priority axes. Nevertheless a bias towards indirect approaches can plausibly be assumed.

Following the classification outlined in figure 1 and 2 direct and indirect approaches account for approximately 37% and 58% of ERDF and ESF funds.[3] The shares clearly differ for East and West German regions. While indirect approaches seem to be comparatively more popular in the New German Laender (61% vs. 53%) direct approaches account for only 33% (vs. 42%).

Indirect approaches place an emphasis on the promotion of (transport) infrastructure and educational achievements. Thus, the efficiency analysis performed in the next section particularly focuses on these two factors.

3 Regions' efficiency in using infrastructure and human capital

Regional efficiency analysis traces back to several studies on the economic performance of Asian regions. Macmillan (1986) and Hashimoto and Ishikawa (1993) applied DEA to rate the efficiency of Chinese and Japanese cities respectively. Charnes et al. (1989) used the same methodology to identify urban industrial performance and assess regional planning tools in China, and Seifert and Zhu (1998) applied DEA to monitor the productivity growth of China's industries over several decades.

More recently regional DEA has been applied to analyze regional efficiency against the background of EU regional policy (Karkazis and Thanassoulis 1998, Castells and Solé-Ollé 2005). This is particularly interesting, as the efficiency argument opens the door for two mutually exclusive investment decisions. A government's objective function could, on the one hand, include the goal to maximize the productivity of funds. Consequentially, investments into rather efficient mostly structurally advanced regions would promise the highest returns (Berhman and Craig 1987). On the other hand, policy makers might aim to minimize the regional disparities – as it is the case for EU's cohesion policy – and funds should particularly be warranted to less efficient structurally disadvantaged regions (Athanassopoulos 1996). The presented study does not question the allocation of funds in absolute monetary terms but rather discusses their composition (with regard to direct and indirect measures) in dependence on the regions' efficiency and income level.

Although DEA has remained a rather popular tool to identify efficiency of firms, studies in the regional regional context often opt for stochastic frontier analyses or parametric efficiency

[3] The remaining 5% are used for technical assistance and the unclassified *Active and preventive measures to support employment*.

measures instead. The advantage of these mostly econometric approaches is seen in the lower degree of uncertainty of the results (e.g. Battese et al., 2004; Meeusen and van den Broeck, 1977). However, there remains a risk that the inference is flawed and the interpretation of the results is uncertain, if the underlying regional production function is wrong (Stolp, 1990, p. 105).

DEA, in contrast, is not dependent on parametric specification but the findings are only driven by observable data. Furthermore, advanced DEA methods, such as bootstrap or outlier robust analyses overcome some of DEA's former shortcomings and allow building confidence intervals for efficiencies, testing hypothesis on returns to scale or excluding outliers (Simar and Wilson, 2008).

The application of these advanced DEA methods in the regional context has only become an issue recently. Focusing on socio-demographics Binder and Broekel (2011), for example, apply an order-m-frontier approach to measure individuals' conversion efficiency of British populace. Schaffer et al. (2011) use the order-α-frontier analysis to calculate the efficiency of German Nuts 3 regions in using infrastructure and human capital to generate per-capita income. The main idea of the order-m- and order-α-frontier analysis is to define an outlier robust efficient boundary. Hence, the frontier does not reflect the highest potential output (for a given set of inputs) but allows outliers to lie outside the boundary (Cazals et al. 2002, Aragon et al. 2005). According to the order-α-approach, regions on the frontier are considered efficient at level α (with an efficiency score $\lambda_\alpha = 1$) and their output is dominated by another region's output (with similar or lower input levels) with a probability $\leq$ 1-α.

In order to apply the order-α-frontier analysis on German Nuts 3 regions and to contrast the findings with the absolute income levels we apply the mathematical model described in full detail by Daouia and Simar (2005, 2007). The input x output space is developed in the following way:

Inputs

A substantial body of indirect regional policy programs focus on the improvement of transport infrastructure and educational achievements. Hence, inputs should reflect these factors.

Regional transport infrastructure is described by a composite indicator that can be subdivided into an internal and external part. The internal part I^{in} basically accounts for the road and railway network density and its potential capacity utilization (Biehl 1995). The external part I^{ex} measures the regions' centrality and is defined as the minimal travel time between the

considered region and other regions by road or rail and the accessible population (Hansen 1959).

(1) $$I_i^{ex} = \sum_{j=1}^{k-1} pop_j \cdot e^{\omega \cdot \min(t_{rail}(i,j), t_{road}(i,j))} \quad , i \neq j$$

k: number of European NUTS 3 regions (EU 25),

pop_j: Population in the European NUTS 3 region j,

t_{rail}: travel time between region i and j by rail,

t_{road}: travel time between region i and j by road.

Parameter ω is a weighting factor that fulfils the following condition:

(2) $$e^{\omega \cdot T} = 0.5 \text{ for T=90 minutes}$$

Thus, a weight of 0.5 is put on the population that can be reached within 90 minutes. The comparatively low half-value period is chosen since most programs intend to improve the link of peripheral regions with the business centres of the federal states. Following this approach the large metropolitan areas of Berlin, Frankfort, Cologne or Munich and their surroundings show the highest values.

In order to account for the educational achievements of the regional workforce, employees are first differentiated according their highest degrees into three groups: employees with lower secondary, upper secondary and tertiary degree. In a second step weights are attributed to the degrees (Schaffer et al. 2011). These derive from the average time use of teachers and professors plus the employees' personal time use for qualification purpose. The weighting factors range from 1 for the first group and 2.6 for the third group (Schaffer and Stahmer 2006). According to this concept the urban districts of Erlangen, Darmstadt, Stuttgart and Jena come up with the highest values in 2004, closely followed by the rural district of the Bodenseekreis.

Output

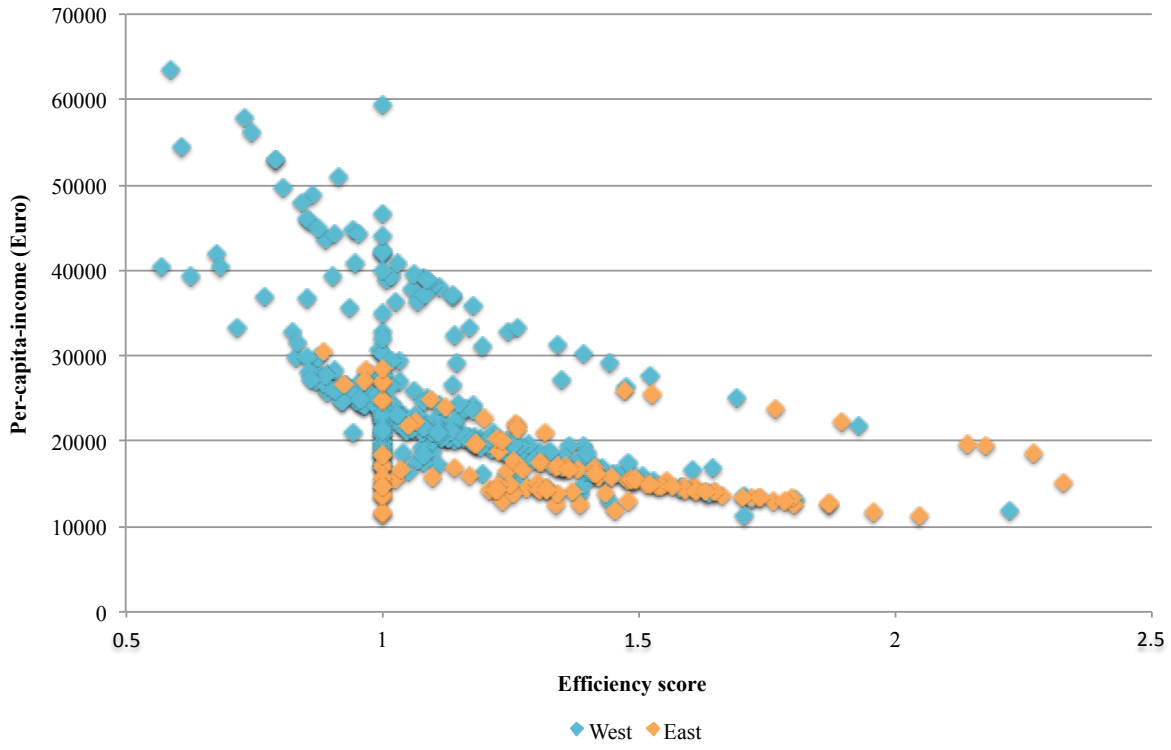
The allocation of funds is often justified by low regional per-capita-income. Hence, this indicator could also be used as output variable for the frontier analysis. However, in this case the number of employees should be included as additional input in order to minimize a potential efficiency bias between regions with the production sites and the surrounding bedtowns.

Alternatively the frontier could reflect regional labour productivity. This is due to the fact that

most programs aim to increase productivity levels (which in turn yields higher income in the long run). The shortcoming of this approach is often related to incomplete regional data on self-employed persons. Despite this shortcoming, which is to some extend valid for this study as well, we choose for the second option and define the output as Gross Regional Product (GRP) divided by the number of employees liable to social insurance. Since the umber of total employees is higher, the indicator does not reflect productivity in a narrower sense but could be considered a good proxy.

Figure 3 shows the efficiency scores and income levels of 439 German Nuts 3 regions. An efficiency score of 1 marks regions on the frontier. Due to the mathematical formulation of the output oriented model regional efficiency decreases with increasing efficiency scores. Thus, scores below 1 point to the (approximately) 10% outliers which lie above the frontier (for α=0.9). In contrast efficiency scores larger than 1 point to comparatively inefficient regions – inefficient in transferring available infrastructure and human capital into labor productivity.

Figure 3. Regional efficiency scores and annual per-capita income for German regions (2004)



The figure suggests a positive correlation of efficiency and income (or a negative correlation of efficiency scores and income) and a simple regression analysis strengthens this intuition with R^2s of 0.35 and 0.42 for a simple linear and exponential regression respectively.

Following traditional DEA, the activity units' efficiency is independent from the efficiency of other units but driven by internal factors. In the context of the presented study, which considers counties as activity units, the economic structure, institutional arrangements, innovation culture etc. can be considered such internal factors.

Despite the undisputed importance of the intraregional factors, regions cannot be regarded as fully independent activity units. On the contrary, regional productivity and economic development is, at least to some extend, affected by the performance of neighboring regions as well.[4] The relevance of both drivers, internal structure and spatial dependence, can be analyzed in more detail by a further decomposition of the efficiency scores, e.g. by applying a geoadditiv regression analysis. This approach is based on structured additive regression analysis and allows including nonparametric (e.g. spatial) parameters (Fahrmeir et al., 2001, Kamman and Wand 2003). Consequentially, efficiency scores can be decomposed into a spatial factor $f_{geo(i)}$ for region i and a normally distributed error term $f_{rand(i)}$, which cannot be explained by the spatial factor but can be interpreted as structural factor (Schaffer et al. 2011):

$$\lambda_{\alpha,i} = f_{geo(i)} + f_{rand(i)} \quad (1)$$

The introduction and minimization of a penalizing term (which in this case yields markov random fields and requires the Markov-chain-Monte-Carlo technique to simulate the results) allows to smooth the spatial factor.[5]

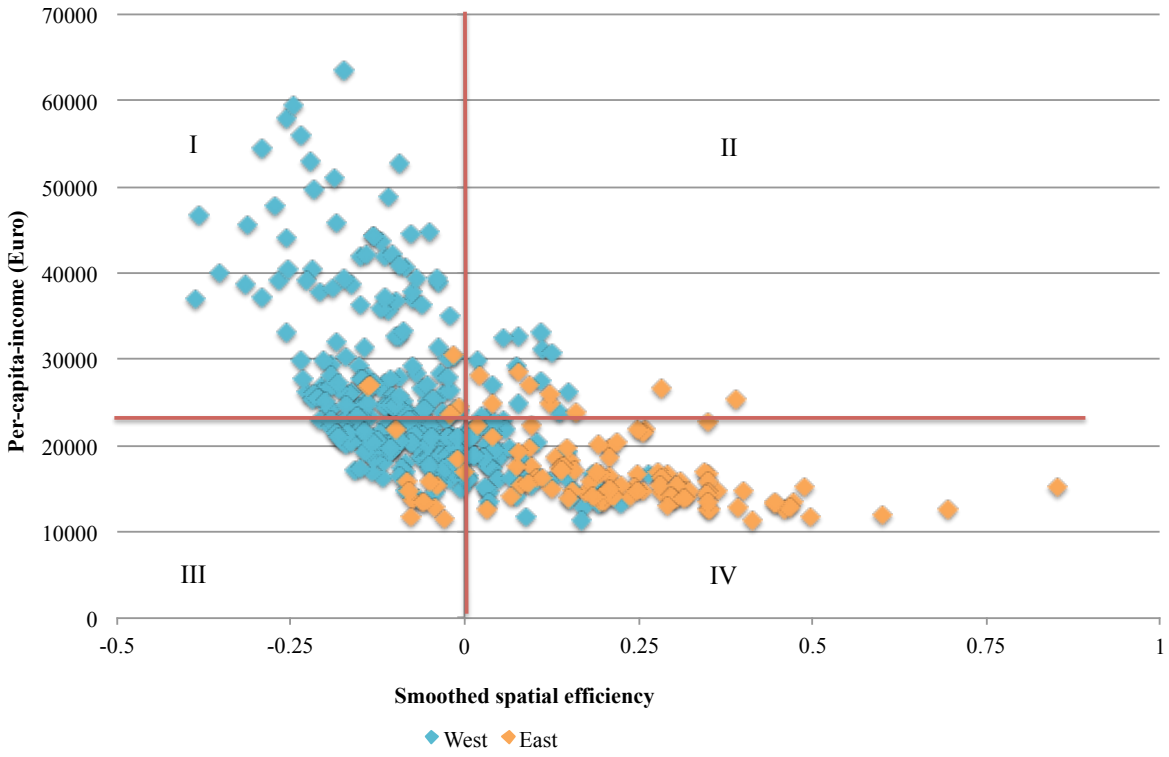
Figure 4 and 5 illustrate the findings of the decomposition and contrast the smoothed spatial and structural efficiency with the per-capita-income. The thick lines mark the average of both categories and therefore subdivide the sample into four groups: releatively rich and efficient regions (first quadrant I), relatively rich and inefficient regions (II), relatively poor and efficient regions (III) and finally relatively poor and inefficient regions (IV).

---

[4] See for example Abreu et al. (2005) for a comprehensive overview of studies using spatial and non-spatial econometric techniques to explain regional growth and productivity.

[5] See Schaffer et al. (2011, Equations 6 to 8) for the mathematical formulation of the smoothing process.

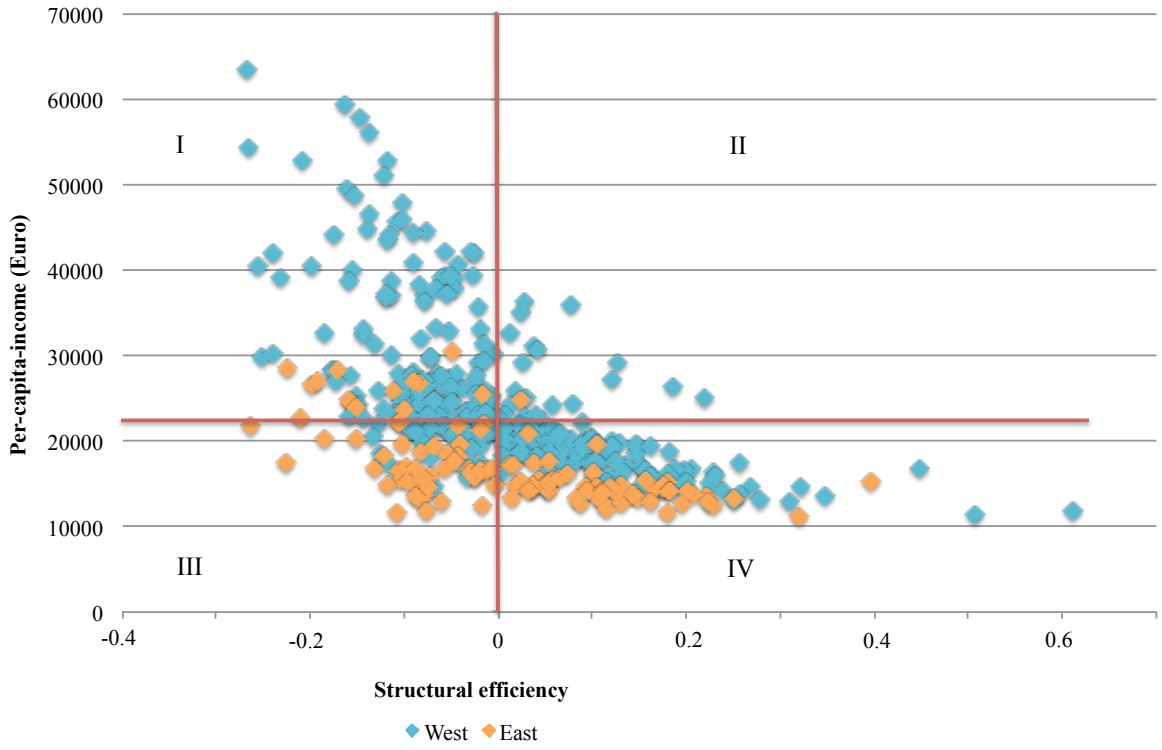
Figure 4. Spatial efficiency and annual per-capita income for German regions (2004)



The positive correlation between income and spatially driven efficiency - R^2's are 0.32 and 0.40 for a simple linear and exponential regression respectively – point to the existence of a clear comparative spatial disadvantage for some German regions. This, in turn justifies the financial support from European, national and federal funds (Athanassopoulos 1996). Furthermore, the composition of the fourth quadrant that encloses relatively poor and inefficient regions confirms East German regions' particular need for funding.

Figure 5 shows the structurally driven efficiency which again correlates positively with regional per-capita-income (R^2's are 0.32 and 0.38 for a simple linear and exponential regression respectively). The results abstract away from smoothed spatial efficiency and focus on intraregional factors. Thus, spatially inefficient regions could indeed turn out to be structurally efficient, if they dominate nearby regions with similar input levels (e.g. greater area of Dresden and Leipzig). Vice versa, spatially efficient regions could be considered structurally inefficient, if they are dominated by nearby regions with similar inputs.

Figure 5. Structural efficiency and annual per-capita income for German regions (2004)



The regional distribution clearly differs from the pattern prevalent in figure 4. A substantial share of East German regions emerge as structurally efficient regions as they move from the second and fourth to the first and third quadrant. On the contrary, quite a number of West German regions moves in the other direction and turns out structurally inefficient.

4 Summary and policy implications

The primary goal of EU regional policy can be seen in the promotion of comparatively disadvantaged regions (generally identified by using per-capita-income as main indicator) and the strengthening of growth and employment in these regions. In order to achieve this objective, regional policy aims to foster eligible regions' attractiveness for private investors. For this purpose two principal lines of actions are followed – the direct and the indirect approach. The first approach addresses investors in a rather direct way by granting financial, technical and managerial support or customized training programs. The second approach seeks to improve the regions' general attractiveness to investors often by promoting infrastructure and human capital.

The success of direct or indirect approaches strongly depends on the regions starting line. Indirect approaches are particularly promising for regions with regularly congested infrastructure and skill shortage. These regions were relatively successful in attracting private

capital in the past and can be expected to be successful in the future – in particular if regional policy helps to alleviate the existing bottleneck in infrastructure or human capital. Regions with a relative shortage in private capital, however, might benefit more from direct approaches while additional provision of public goods might have minor effects in this case.

The efficiency concept presented in this paper allows for the consideration of this issue in order to implement more effective funding schemes. Regions with a comparative spatial disadvantage have a clear need for funding, in particular since this correlates strongly with low per-capita income. But most likely the needs of these regions are heterogeneous.

Structurally relatively inefficient (and poor) regions' ability to attract private capital and subsequently to generate income is too low relative to the available human capital and public infrastructure. Thus, the potential stimulation of the economy induced by an additional unit of public goods is probably modest in nature. As a consequence, regional funding should focus on structural inputs in the form of direct investments to strengthen small and medium sized enterprises and to encourage the foundation of new companies.

On the contrary, poor but structurally efficient regions are comparatively more successful in the attraction of private capital. Hence, the provision of public goods, namely modern infrastructure and improved institutional education, might turn out to be more effective compared to direct investments initiated by regional policy-makers.

Tracing back factual funding patterns of German counties is not an easy task. However, based on a rather small, not representative sample, it looks like the opposite trend can be observed. Structurally inefficient regions often aim to further improve their overall competitiveness by a various number of (often not synchronized) indirect programs and seem to be afraid of specific direct programs. The focus on indirect measures is indeed reasonable for regions disposing of minimum absolute levels of infrastructure and human capital. But once a certain threshold is achieved, policy makers should turn their attention to direct measures.

In contrast, structurally efficient and comparatively competitive regions seem to have a preference for direct approaches. This, in turn, yields further growth but also congestion and skill shortage.

From a centralized point of view such a funding pattern could even widen rather than closing the income gap among regions.

It can be concluded that a customized differentiation of financial aid into direct job creating investments and the enhanced provision of public goods could increase the overall productivity of regional funds. However, the preference for a more precise funding, based on the regions' efficiency, should not be seen as an advocate for exclusive investments of one or

the other form. It rather supports the idea of a more region-specific financial aid while still having in mind the complementarity of different kinds of funding.

References

Abreu, M. M., de Groot, H. L., Florax, R. J. (2005), Space and growth: A survey of empirical evidence and methods, *Région et Dévelopment*, 21: 13–44.

Aragon, Y., Daouia, A., Thomas-Agnan, C. (2005) Nonparametric frontier estimation: a conditional quantile-based approach, *Econometric Theory* 21: 358-389.

Athanassopoulos, A. D., (1996), Assessing the comparative spatial disadvantage (CSD) of regions in the European Union using non-radial data envelopment analysis methods, *Journal of Operational Research* 94: 439-452.

Battese, G. E., Prasada Rao, D. S., O'Donnell, C. J. (2004), A metafrontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies, *Journal of Productivity Analysis*, 21(1): 91–103.

Biehl, D. (1995), Infrastruktur als Bestimmungsfaktor regionaler Entwicklungspotentiale in der Europäischen Union, in: Karl, H., Heinrichsmeyer, W. (Ed.) *Regionalentwicklung im Prozess der Europäischen Union*, Bonner Schriften zur Integration Europas, 59-86.

Binder, M. and Broekel, T. (2011), Applying A Nonparametric Efficiency Analysis to Measure Conversion Efficiency in Great Britain, *Journal of Human Development and Capabilities*, 12(2): 257-281.

Castells, A, Solé-Ollé, A. (2005), The regional allocation of infrastructure investment: The role of equity, efficiency and political factors, *European Economic Review* 49: 1165-1205.

Cazals, C., Florens, J. P., Simar, L. (2002), Nonparametric frontier estimation: a robust approach, *Journal of Econometrics* 106: 1-25.

Charnes, A., Cooper, W. W., Li, S. (1989), Using data envelopment analysis to evaluate efficiency in the economic performance of Chinese cities, *Socio-economic Planning Science* 23: 325-344.

Daouia, A, Simar, L. (2005), Robust nonparametric estimators of monotone boundaries, *Journal of Multivariate Analysis* 96: 311-331.

Daouia, A., Simar, L. (2007), Nonparametric efficiency analysis: a multivariate conditional quantile approach, *Journal of Econometrics*, 140: 375–400.

Die Bundesregierung (2011), Europäischer Sozialfonds für Deutschland, Förderperiode 2007-2013, http://www.esf.de/portal/generator/656/programme__2007-2013.html, June 2011.

European Commission (2007), Cohesion policy 2007-2013, Commentaries and official texts,

The European Ciommunities: Brussels.

European Commission (2011), Regional Policy – Inforegio, European Union 1995-2011, http://ec.europa.eu/regional_policy/country/prordn/index_en.cfm, June 2011.

Fahrmeier, L., Tutz, G., Hennevogl, W. (2001), *Multivariate statistical modelling based on generalized linear models*, Springer: New York.

Hansen, W. G. (1959): How Accessibility Shapes Land Use, *Journal of the American Institute of Planners*, 25(2): 73–76.

Hashimoto, A., Ishikawa, H. (1993), Using DEA to evaluate the state of society as measured by multiple social indicators, *Socio-Economic Planning Sciences* 27: 257-268.

Kammann, E. E., Wand, M. P. (2003), Geoadditive models, *Applied Statistics*, 52(1): 1–18.

Karkazis, J., Thanassoulis, E. (1998), Assessing the Effectiveness of Regional Development Policies in Northern Greece Using Data Envelopment Analysis, *Socio-Economic Planning Sciences* 32/2: 123-137

Macmillan, W. (1986), The estimation and application of multi-regional economic planning models using data envelopment analysis, *Journal of Regional Science* 60: 41-57.

Meeusen, W., van den Broeck, J. (1977), Efficiency estimation from Cobb-Douglas production functions with composed error, *International Economic Review*, 18: 435–444.

Schaffer, A., Stahmer, C. (2006), Women's GDP – A Time-based Input-Output Analysis, *Swiss Journal of Economics and Statistics,* 142: 367-394.

Schaffer, A., Simar, L., Rauland, J. (2011), Decomposing Regional Efficiency, Journal of Regional Science, forthcoming, doi: 10.1111/j.1467-9787.2011.00731.x

Seifert, M. L., Zhu, J. (1998), Identifying excesses and deficits in Chinese industrial productivity (1953-1990): A weighted data environment analysis approach, *Omega* 26/2: 279-296.

Simar, L., Wilson, P. W. (2008), Statistical Inference in Nonparametric Frontier Models: recent developments and perspectives, in: Fried, H., Lovell, C. A. K., Schmidt, S. (eds.), *The Measurement of Productive Efficiency*. Oxford: Oxford University Press, pp. 421–521.

Stolp, C. (1990), Strengths and weaknesses of data envelopment analysis: An urban and regional perspective, *Computers, Environment and Urban Systems*, 14(2): 103–116.

Working Paper Series in Economics

recent issues

No. 31 *Axel Schaffer:* Appropriate policy measures to attract private capital in consideration of regional efficiency in using infrastructure and human capital, July 2011

No. 30 *Stoyan V. Stoyanov, Svetlozar T. Rachev, Boryana Racheva-Iotova, Frank J. Fabozzi:* Fat-tailed models for risk estimation, May 2011

No. 29 *Stoyan V. Stoyanov, Svetlozar T. Rachev, Frank J. Fabozzi:* CVaR sensitivity with respect to tail thickness, May 2011

No. 28 *Young Shin Kim, Svetlozar T. Rachev, Michele Leonardo Bianchi, Frank J. Fabozzi:* Tempered stable and tempered infinitely divisible GARCH models, May 2011

No. 27 *Takashi Kanamura, Svetlozar T. Rachev, Frank J. Fabozzi:* A profit model for spread trading with an application to energy futures, May 2011

No. 26 *Michele Leonardo Bianchi, Svetlozar T. Rachev, Young Shin Kim, Frank J. Fabozzi:* Tempered infinitely divisible distributions and processes, May 2011

No. 25 *Sebastian Kube, Michel André Maréchal and Clemens Puppe:* The currency of reciprocity - gift-exchange in the workplace, April 2011

No. 24 *Clemens Puppe and Attila Tasnádi:* Axiomatic districting, April 2011

No. 23 *Dinko Dimitrov and Clemens Puppe:* Non-bossy social classification, April 2011

No. 22 *Kim Kaivanto and Eike B. Kroll:* Negative recency, randomization device choice, and reduction of compound lotteries, April 2011

No. 21 *Antje Schimke and Thomas Brenner:* Long-run factors of firm growth - a study of German firms, April 2011