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Abstract

German structural policy is characterized by a composite indicator with three targets: (1) minimization of unemployment, (2) maximization of GDP, and (3) equalization of regional unemployment rates. The composite indicator with given target weights is maximized subject to budget constraints and some administrative restrictions. The optimal combinations of target indices obtained for variable weight ratios are to be considered by a policy maker who thereby makes the final choice among already optimized outcomes, not being burdened with adjusting the target weights. The optimization is performed for econometric predictions-2004 which are derived from regional data for 1994–2002.

Comparing with the optimal budget distribution, the efficiency of the actual "manual" budget distribution in 2000–2002 is about 4%, that is, the results actually obtained for 6 Bio. EUR could be obtained for 241 Mio. EUR (= 4% of the actual budget). Such a bad implementation of active labour market policies can be responsible for their low efficiency reported in some empirical studies and misinterpreted as their uselessness. Besides, it is found that the most productive jobs (most contributing to GDP) require least subsidies. Finally, taxes expected from new jobs allow to consider the problem from a managerial viewpoint. In particular, the government can maximize tax returns from investments in labour market policies.

Keywords: European Commission, structural funds, regional policy, active labour market policies, equalizing regional unemployment rates, economic growth, optimal planning, governmental management.

JEL classification: C33, H25, J68, R00, R15.

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Contents

1 Introduction

Structural and regional policy Increasing employment, stimulating economic growth, and reducing disparities among regions are objectives of both German and European structural and regional policies. In recent years multi-billion national and European grants were given to bring regional unemployment down to the national average by creating new and/or safeguarding existing jobs. In particular, a European grant within Structural Funds' Objective 1 (European Commission 2005) contributes to the German governmental program for equalizing regional unemployment (Deutscher Bundestag 2002, Tetsch et al. 1996), which also contributes to reducing the general unemployment and to increasing GDP due to new jobs.

Equalization of unemployment resembles the stabilization of an airplane. The stabilizer consumes some energy but is necessary to provide a safe flight. The equalization of unemployment takes resources from active labor market policies but is required to prevent structural disproportions.

Limited resources naturally tempt to subsidize 'cheap' jobs which need less subsidies rather than the jobs which are 'expensive' for grant-givers. The evident reason is that then more jobs can be created or safeguarded. Since the amount of aid per job depends on specific regional industries and services, certain regions can be little supported, while others get too much aid. This decreases the national unemployment but increases the disparity among regions. Besides, large deviations from the starting point make accurate predictions impossible putting in question the model adequacy. Thus, equalization of regional unemployment rates is important not only to avoid structural disproportions but also to keep the situation under operational control.

It should be emphasized that no budget distribution among 271 regions can be optimized 'manually', without modern computational facilities. Even simplest decisions "to subsidize the region or not" result in 2^{271} distribution variants which number much surpasses the number of atoms in the Universe. Such a huge number of possibilities leaves no chance to solve the problem by any normative 'manual' rule.

Regional unemployment The regional unemployment rate is one of most important indicators of socio-economical equilibrium. It characterizes the regional governmental performance and serves as a governmental assistance criterion. Moreover, its equalization all over the country is expected to improve national output as well as to decrease inflation pressure (Taylor 1996).

According to Fothergill (2001) and Elhorst (2003), the unemployment disparity among regions within countries is becoming a source of trouble in the European Union. They are getting comparable with that among the countries themselves (Elhorst 1995, Taylor and Bradley 1997, European Commission 1999). The extension of the European Union to the East, where the economical imbalance is aggravated by transition processes, makes this problem even more acute.

Comparing with unemployment at national and international levels, regional unemployment is relatively little studied. The 3630 page *Handbook of Labor Economics* (Ashenfelter and Layard 1986, Ashenfelter and Card 1999) contains nothing on regional unemployment, and the *Handbook of Regional and Urban Economics* contains only a half-relevant chapter on urban unemployment (Crampton 1999). All of this illustrates how far the topic is from the mainstream research.

The belief that the nature of regional unemployment is similar to that of unemployment in general is rather superficial. The factors which are thought to explain disparities among countries (e.g., Phelps 1994, Malinvaud 1994, Bean 1994, OECD 1994, Scarpetta 1996), like institutions of wage bargaining, social security, retirement, and taxes are not relevant to regions. Indeed, they differ between countries but not between regions within countries; consequently some other factors should exist.

Elhorst (2003) has reviewed 41 empirical studies, where regional unemployment differentials are explained with the help of regional data. These models (not necessarily formal) are classified as follows:

1. Single equation models (one independent and one dependent variable):
   (a) *empirical models*, mostly with no equations but nevertheless suggesting factors which might be used as explanatory variables,
   (b) *the inverse unemployment-vacancy relationship*, or the Beveridge curve (e.g., Jones and Manning 1992, Holzer 1993),
   (c) *the cyclical sensitivity model* which explains the regional unemployment as a linear function of the national unemployment; such a model makes sense if the regional and national unemployment *cointegrate* in the sense of Engle and Granger (1987) into an equilibrium configuration (e.g., Chapman 1991, Martin 1997, Baddeley et al. 1998),
   (d) *the amenity model* which explains the regional unemployment as a function of aggregated attractiveness of the regions, for instance, reflected by the wage-to-infrastructure-index ratio (e.g., Marston 1985, Montgomery 1993).

2. Implicit models
   (a) *the migration-based model* which explains the regional unemployment by migration flows (e.g., Molho 1995, Groenewold 1997),
   (b) *the NAIRU model* (= non-accelerating inflation rates of unemployment), or the Phillips and wage-setting curves (e.g., Jones and Hyclak 1989, Payne 1995),
   (c) *the Blanchard–Katz model* (1992) with four equations which links the regional unemployment rate to labor supply, labor demand, wage-setting, and migration of both population and firms; a similar study on the regional unemployment in the European Union is performed by Decressin and Fatás (1995).

3. The accounting identity models which are based on estimating the impact of a single individual, depending on his identification either as a local unemployed, or migrant, in-commuter, or out-commuter, etc. (e.g., Burridge and Gordon 1981, Gordon 1988, Gordijn and Wissen 1992, Wissen and Ekamper 1995).

4. The simultaneous models with interactions, which take into account the feedback of the regional unemployment to the explanatory labor market variables, like the labor force participation rate, degree of employment and earnings, labor demand, etc. (e.g., Bilger et al. 1991, Blackaby and Manning 1992).

As concluded by Elhorst, the models reviewed provide clear-cut trends in the interaction between the regional unemployment and other labor market variables. It should be noted however that these models directly or indirectly assume a kind of labor market equilibrium, which is a certain idealization. The factors which violate the equilibrium, like governmental creation of new jobs, are not explicitly taken into account.

Active labor market policies Active labor market policies are aimed at reducing unemployment and are implemented in all developed countries (Fay 1996, Heckman et al. 1999, Martin 2000, Steiner and Hagen 2002). They fall into three main schemes.

1. *Job creation* is offering subsidies to wages mainly for short-running projects in non-profit organizations. These jobs are often given to former long-term unemployed and are usually restricted to terms of about one year.

2. *Structural adjustments* is also offering wage subsidies but with other goals and in a closer collaboration with private firms. The subsidies are aimed at integrating the employees into the main activities and are given for terms of about three years.

3. *Public training* consists of educational measures paid by the employment office. They are aimed at improving the chances for employment and increasing the employment stability.

According to Bundesanstalt für Arbeit (2003b), during the period of 1990–2002 only in East Germany 6.5 Mio workers, which is about the number of active employees, were involved in these programs with the overall budget of 138 billion EURO. Expenditures of this size require systematic analysis of their effects.

Microeconomic studies are based on comparisons between groups of participants and groups of non-participants; for surveys see Hagen and Steiner (2000) and Hujer and Caliendo (2001). As follows from these surveys, there is no clear evidence of either positive, or negative effects of the German active labor market policies on the future prospects of the participants. This indefiniteness has been also confirmed by the recent report based on large administrative data (Hujer et al. 2003).

Hagen (2003) criticizes the microeconomic approach for its *stable unit treatment value assumption* (Rubin 1980). In the given context it means that the control groups of non-participants are not affected by the programs. Since the programs are very extensive, their indirect effects on the non-participants are likely to be quite significant. It implies a violation of the basic assumption, making questionable their results.

The macroeconomic approach, on the contrary, assumes simultaneity and reciprocal influence of all factors within the economy. Several authors selected it as more appropriate for estimating the indirect and *net* effects of active labor market policies (Heckman et al. 1999). However, macroeconomic studies based on regional data reveal no unambiguous trends either (Büttner and Pray 1998, Steiner et al. 1998, Hagen and Steiner 2000, Schmid et al. 2001, Blien et al. 2002, Fertig et al. 2002, Hagen 2003).

In the most recent study Hagen (2003) applied three macroeconomic approaches to East German regional data:

- an augmented matching function approach which evaluates the effects of the active labor market policies on regional matching efficiency,

- a reduced-form approach based on the Beveridge curve which assesses the effects on the regional job seeker rate, including both unemployed and participants in the active labor market policies,
- a regional labor demand approach.

The main findings were a certain negative effect of job creation and no significant effect of structural adjustments and of public training on the regional employment. In spite of having used alternative approaches, a number of questions remained open.

It should be noticed that both micro- and macro- modelling do not take account of such general factors as accelerating technological transformations with new requirements to the employees, support of Eastern Europe and globalization which channelled financial flows out of developed countries and moved some industries and services to the Third World, and the recession which started in Asia in the mid-1990s and then expanded to the West. Their negative implications can mask the positive effect of the active labor market policies, without which the labor market situation might become much worse.

Structural policy and optimization Much less attention is paid to the quality of realizing governmental programs (Bradley et al. 2003). According to Lechner and Smith (2003), "caseworkers do not do a very good job of allocating their unemployed clients to the subprograms so as to maximize their subsequent employment prospects." A bad implementation of subsidizing policies (= non-optimal resource allocation with respect to objectives) can be responsible for their low efficiency reported in some empirical studies and misinterpreted as their uselessness.

In a market economy, underused possibilities and non-optimal behavior often cause redistributions and structural shifts which can lead away from the results expected. For instance, an imbalanced job creation in one region causes migrations to the region, implying that the regional unemployment rate decreases much less than intended.

Lechner and his colleagues (2003) took part in developing an expert system which customizes the offer for each particular unemployed client. This may be the only (and unconscious!) instance of any kind of optimization approach in the vast research on active labor market policies[2].

Such a general neglect of optimization methods is amazing in two respects. The role which optimization plays in the modern economy is hard to overestimate (Samuelson 1971). The market economy optimizes itself being guided by 'the invisible hand', Adam Smith's (1776) metaphor for competition. However, it is not the case of public sector with its central planning and governmental budget programs. The problems here range from simple inefficiency to non-optimal interventions into market economy which destroy its self-regulation. Consequently, optimization should be primarily used in the public sector and particularly in the domain discussed.

On the other hand, almost all quantitative studies on unemployment are essentially econometrical. Yet the founders of econometrics, the first winners of the Nobel Prize in economics 1969, Jan Tinbergen and Ragnar Frisch, always linked econometrics to

[2]In a personal communication Lechner was somewhat surprised to learn about the optimization interpretation of his work. Elhorst after having compiled a comprehensive survey was not aware of any optimization approach.

optimization. Among other things, both Tinbergen and Frisch were faced with unemployment problems and in the 1950s made pioneering contributions to econometric optimization models (Frisch 1963, Tinbergen 1952, 1956, see also Johansen 1974); this topic was selected by Frisch for his Nobel Address (1970). Consequently, there are also historical prerequisites for interactions between unemployment studies, econometrics, and optimization.

In econometric optimization models the desired is represented by the objective function and the feasible by econometric equations which restrict economic indices to certain attainable combinations. Their interaction results in the optimal decision. In a sense, optimization adds an active element, the choice, to descriptive econometric models, making the next step in controlling the situation.

Econometric decision models Just this philosophy was developed by R. Frisch and J. Tinbergen. For the first time, the term 'decision model' (= econometric optimization model) was used in Frisch's work for the United Nations Economic and Employment Commission in 1949 (Bjerkholt and Strøm 2002). This work was published as late as in 1955 and the idea of decision models became popular owing to Tinbergen's *On the Theory of Economic Policy* (1952) where he acknowledged Frisch's priority. Both Tinbergen and Frisch strongly promoted the so-called quadratic-linear approach with a quadratic objective function maximized or minimized subject to linear constraints.

The bottle-neck was the objective function, and Frisch (1957, 1971) suggested the *Multiplex Method* to construct it from interviews. In the mid-1950s he conducted "well planned interviews" with the Norwegian Minister of Finance Trygve Bratteli who became Prime Minister for the Labour Party in the early 1970s. Later this approach was tentatively used by Van Eijk and Sandee (1959), Chossudovsky (1972a–b), Van der Geest (1977), Merkies and Nijman (1983), Van Daal and Merkies (1984), Merkies and Hofkies (1991), Hüsges and Gruber (1991), and Medelin, Aspedale and Pachio (1994).

Frisch intended objective functions for decision models, but these plans had few successors. Frisch's ideas were not really elaborated but only discussed by Hallet and Rees (1983), Rustem and Velupillai (1984), Hughes Hallet (1991), and some others. In particular, Oswald (1985) explained perspectives of using econometric decision models for the wage formation. Recovering objective functions of trade union leaders and of leaders of employer's associations were supposed to imply the tradeoff between wage level and unemployment.

Tinbergen payed a considerable attention to econometric decision models but was inclined to derive the objective function from the formulation of the problem rather than from interviews (Kol and de Wolf 1993). Many of his objective functions are linear, but some are quadratic. It is the case of the model with fixed targets (= the ideal combination of variables), where the distance to the given point is minimized (Tinbergen 1956).[3] Tinbergen's approach was further developed by Theil (1964), Fox et al. (1966),

[3] Rigorously speaking, it is difficult to avoid subjectivity even here. The distance in the econometric space is ill-defined. Axes are measured in different units like percent of inflation, number of jobs, Mio. dollar, etc. Even expressing all quantities in percent is of little help, since, for instance, one percent of inflation and one percent of unemployment can be hardly compared. Determining their substitution rates brings the problem back to Frisch's interviews. The question is relevant to regression models which fit hyperplanes to points with heterogeneous coordinates. Therefore, Frish's thoughts deal also with the

Chow (1975) and other leading economists.

Tinbergen's view at econometric decision models was 'more objectivistic' than that of Frisch. Deriving objective functions from sources other than interviews looked more impartial and 'scientific'. Sharing this standpoint, several authors revealed objective functions from panel data, in particular from tradeoffs observed. These studies are however not quite relevant to proper decision models, since they are not aimed at finding decisions but operate on the ones already made (like consumer choices). Moreover, a 'decision' is regarded as a kind of equilibrium-based optimization which is not exactly the subject of decision models. For a survey of related works see Dantzig at al. (1989a–b) where the objective function of the U.S. economy is constructed.

Tinbergen and his successors often considered abstract objective functions for analytical purposes, without numerically determining their coefficients. The linear-quadratic decision model which seemed quite operational was rather a theoretical framework. Persistent Frisch's efforts to develop methods for constructing objective functions were not more than practice-*oriented*. As concluded by Bjerkholt (the editor of selected essays by R.Frisch) and Strøm (2002), "Frisch left this field of interest with work undone".

Objective functions and composite indicators In subsequent years the situation did not improve much. A number of experiments are reported by Merkies and colleagues; see Merkies (2002) for a survey. Special methods for constructing quadratic and additive objective functions are developed by Tangian (2002, 2004).

A new wave of interest to constructing objective functions emerged due to the propagation of composite indicators which appear in numerous world-wide documents (United Nations 2001–, International Institute for Management Development 2000–, World Economic Forum 2002–, OECD 2002–2004). On October 2001 the European Commission recommended to develop composite indicators for certain purposes within the Structural Indicators Exercise (European Commission 2001a) which was followed by the report (European Commission 2002b). As emphasized by the OECD (2003, p. 3),

> Composite indicators are valued for their ability to integrate large amounts of information into easily understood formats for a general audience... Despite their many deficiencies, composite indicators will continue to be developed due to their usefulness...

Composite indicators are highly appreciated in international comparisons, where it is often required to surmount national particularities and to bring the consideration to the common denominator. As noted by Munda and Nardo (2003, p. 2),

> Composite indicators stem from the need to rank countries and benchmarking their performance whenever a country does not perform strictly better than another. Composite indicators are very common in fields such as economic and business statistics (e.g., the OECD Composite Leading Indicators) and are used in a variety of policy domains such as industrial competitiveness, sustainable development, quality of life assessment, globalization and innovation (see Cox and others 1992, Huggins 2003, Wilson and Jones 2002, Guerard

general adequacy of econometric equations.

2001, Färe et al. 1994, Lovell et al. 1995, Griliches 1990 and Saisana and Tarantola 2002, among others)... A general objective of most of these indicators is the ranking of countries according to some aggregated dimensions (see Cherchye 2001 and Kleinknecht 2002).

A composite indicator is defined to be a weighted sum of several first-level indicators which weights reflect their substitution rates; see European Commission (2002c, p. 79), OECD (2003, p. 5), and Munda and Nardo (2003, p. 2). In other words, composite indicators are simplest objective functions. Specificity of composite indicators, their typology, requirements for input data, principles of weight assignments, and other issues are reviewed by Bossel (1999), Huggins (2003), and Saisana and Tarantola (2002). Practical aspects of composite indicators are outlined in brief guides by the OECD (2002, 2003), Pastille (2002), and Sendzimir (2004).

The difference between composite indicators and objective functions (= utility functions) is rather methodological. The latter are used to represent individual or social preferences. Composite indicators reflect development of and differences between alternatives; they however are also often charged with a better/worse inclination. In this case they are at the same time objective functions, even if considered outside of optimization models ("Indicators create leverage power that can change the future"; see Sendzimir 2004, p. 4). To provide compatibility of scales, composite indicators are defined in standardized input variables. This is equally relevant to objective functions but only less emphasized. In most cases both terms are synonyms but "composite indicator" may just better fit to the linguistic context. For instance, it is more natural to speak of a composite indicator of regional performance which contributes to that of national performance than of a utility sub-function.

Due to some fundamental difficulties of preference aggregation in multi-criteria analysis (Arrow and Raynaud 1986), universal constructing methods exist neither for objective functions, nor for composite indicators. In each case their construction is much determined by the particular application, includes both formal and heuristic elements, and incorporates some expert knowledge on the phenomenon; see proceedings of dedicated conferences on composite indicators organized by the Joint Research Center of European Communities and the OECD (Saltelli 2003a–b and Hoffmann 2004).

Regardless of the progress in constructing objective functions and composite indicators, building an econometric decision model still remains to be a kind of art. Firstly, it needs a specific knowledge of the subject domain. Secondly, selecting important factors, sorting out secondary ones, and formalizing ill-defined notions, relations, and preferences by variables, equalities, inequalities, and functions requires intuition and inventiveness. Thirdly, configuring sophisticated optimization methods into a consistent model needs mathematical skills. Finally, the whole construct must be mathematically manageable and computable.

About the given work The given work combines methods for constructing objective functions and composite indicators with the ideology of econometric decision models. The whole is aimed at optimizing a large-scale budgeting program of governmental subsidies to regional labour markets.

At present Germany is divided into 271 labor market regions, 204 in West Germany and 67 in East Germany. The European employment policy restricts the regions to be supported to 23.4% of the total population (Crome and Schwengler 2000, Hassold and Jung 2000). Taking into account economic difficulties in East Germany, all its regions are eligible, and the budget is separate for West and East Germany. During the control period 1994–2002 all eligible regions received yearly about 2.0–2.8 Bio EUR; West Germany received about 250–280 Mio, about 1/9, and East Germany — 2.0–2.5.1 Bio, 8/9 of the total. It should be mentioned that some West German regions were eligible for a few years or for one year only, and some regions were not eligible at all. It implies fewer data on West Germany and blanks in corresponding data tables.

In the given paper we develop an econometric decision model for redistributing the aid among eligible regions in East and West Germany. The optimization is performed to increase in (a) employment and (b) GDP as well as (c) to equalize regional unemployment rates, according to the goals of European and national structural policies. The model operates on regional indicators 1994-2002 available from Bundesamt für Wirtschaft und Ausfuhrkontrolle (2003), Bundesanstalt für Arbeit (2003a), and Statistisches Bundesamt (2003). It consists of three main blocks:

1. Econometric predictions: Explaining regional indices as functions in year and regional subsidies

   Effects of active labor market policies on the regional indices, in particular on unemployment, have been outlined in Section 1. As revealed by Hagen (2003) and several other authors, the regional unemployment rates depend on the subsidies granted to the regions. For our study, we use the simplest linear estimation directly derived from the available statistical figures.

2. Budget optimization for the situation predicted

   - Operationalizing the target variables

     The econometric regional prediction of unemployment and the increase in GDP imply simple linear expressions for the national unemployment rate and the GDP gain. The unemployment disparity among regions is defined to be the variance of regional unemployment rates.

     The criterion of least variance, not always explicitly, is used in models of market stabilization (Gruber 1965, 1967), general economic stabilization (Pindyck 1973, Friedman 1975), and optimal control (Chow 1975, Blanchard and Fischer 1989).

   - Expressing the target variables in regional subsidies

     The linear econometric equations, having been substituted into linear expressions for national unemployment or GDP gain, and in the quadratic expression for the variance, do not affect their (polynomial) degree. This means that the first two target variables, having been expressed in the regional subsidies, remain linear functions, and the third target variable, the variance, remains quadratic.

   - Normalizing the target variables

     To avoid scaling effects and to surmount the heterogeneity of units of measurement, the target variables are reduced to the standard range 0–1.

- COMPOSITE INDICATOR OF REGIONAL POLICY AS THE OBJECTIVE FUNCTION

  The objective function is defined to be a composite indicator of regional policy. Consequently, it is a weighted sum of the three target variables expressed in subsidies to regions. The target weights, reflecting the relative importance of targets (substitution rates), are to be adjusted later. The resulting objective function is quadratic because of the quadratic third target (variance or regional unemployment rates).

- OPTIMIZATION MODEL

  The optimization problem is linear-quadratic, with a quadratic objective function minimized subject to a linear budget constraint and eligibility restrictions. It is solved with a MATLAB computer program.

3. USER INTERFACE TO ANALYZE OPTIMAL SOLUTIONS AND INTERACTIVE FEEDBACK-BASED ADJUSTMENTS

   The optimization is performed for West Germany and East Germany with separate budgets, as well as for the whole of Germany with a joint budget. Tabular and graphical output enables to adjust target weights interactively with respect to attainable outcomes, as well as with respect to tax returns from the jobs subsidized.

Chapter 2, "Model", contains rigorous assumptions and mathematical propositions, as well as the description of the model design. The 'motor' is Theil's (1971, p. 12) vector/matrix representation of the variance which separates linear and quadratic operations, and thereby makes the optimization problem solvable.

Chapter 3, "Analysis of the past practice", contains the comparison of the results actually obtained in 2000–2002 with the ones which could be obtained if the optimization model were used. It is shown that the same control indicators could be obtained with only 4% of the actual budget (241 Mio. EUR instead of 6 Bio. EUR), meaning that the efficiency of optimal planning is 25 times higher.

Chapter 4, "Managing regional policy", explains how to interactively adjust target weights to the end of implementing intentions of the policy maker. The tabular and graphical interface to the model is based on the triangle of priorities 'Employment—GDP—Equalization of regions'. It allows to trace the output implications from positioning within the triangle and to predict tax returns from new or safeguarded jobs.

The last chapter "Conclusion" outlines perspectives for further developments and recapitulates the main results of the paper.

2 Model

Empirical data 1994–2002 and variables derived Table 1 provides a sample of source data and of their transformation into the model variables. In the interest of saving space, only the first 10 records of the year 1994 are displayed in Table 1, but the data were compiled for all 271 regions for the years 1994–2001. Blank spaces mean that the region received no aid on the given year, like Heide, Hamburg, Braunschweig, and Salzgitter. The productivity (= GDP per employee) reflects the competitive standing of the region.

Table 1: Sample source data 1994 and their transformation into regional variables

Nr.	Region	Source data					Variables (data derivatives)			
		Employed	Unemployed	GDP	Aid to the region	Number of permanent jobs subsidized	Net employed (as if with no aid)	Net unemployed (as if with no aid)	Productivity (GDP/ Num.of empl.)	Aid per job subsidized
		Ths	Ths	Mio.EUR	Mio.EUR	Ths.	Ths	Ths	Ths.EUR	Ths.EUR
1	Husum	75.30	4.00	2895	0.560	0.030	75.27	4.03	38.4	18.67
2	Heide	54.70	4.00	2308			54.70	4.00	42.2	
3	Itzehoe	53.50	4.30	2791	0.800	0.130	53.37	4.43	52.2	6.15
4	Flensburg	128.90	10.60	5411	11.350	0.234	128.67	10.83	42.0	48.50
5	Lübeck	197.80	16.70	8277	0.030	0.003	197.80	16.70	41.8	10.00
6	Kiel	336.10	29.40	15111	0.220	0.039	336.06	29.44	45.0	5.64
7	Ratzeburg	56.80	4.80	2514	0.570	0.165	56.63	4.96	44.3	3.45
8	Hamburg	1388.40	97.20	79859			1388.40	97.20	57.5	
9	Braunschweig	220.50	23.90	10283			220.50	23.90	46.6	
10	Salzgitter	57.90	7.60	2901			57.90	7.60	50.1	
...										

The four variables are derived from the source data as follows:

$$\begin{aligned}
\text{Net employed} &= \text{Number of employed} \\
&\quad -\text{Number of permanent jobs subsidized} \quad \text{(in Ths)} \\
\text{Net unemployed} &= \text{Number of unemployed} \\
&\quad +\text{Number of permanent jobs subsidized} \quad \text{(in Ths)} \\
\text{Productivity} &= \frac{\text{GDP}}{\text{Number of employed}} \quad \text{(in Ths EUR/employee)} \\
\text{Aid per job subsidized} &= \frac{\text{Aid to the region}}{\text{Number of permanent jobs subsidized}} \quad \text{(in Ths EUR/job)}
\end{aligned}$$

The number of net employed and of net unemployed are computed assuming no external interventions such as the creation of new and/or safeguarding existing jobs.

The productivity reflects the competitive standing of the region. Supporting productive regions implies developing industries and services with an important contribution to GDP.

The aid per job is in fact the price of one job for grant givers. Subsidizing the regions where this price is low implies a high effect of the grant, because more jobs can be subsidized for the same aid. On the other hand, 'cheap' jobs, requiring little investments, are suspected of belonging to low productive branches with simple working equipment. Our study however disproves this hypothesis.

Econometric forecast for 2004 For each of the 271 regions, the four model variables are time series for 1994–2001. The next step is to predict their $271 \times 4 = 1084$ values for the year 2004. It is done by common linear regression techniques. The prediction is made whenever the data on the region are available (also for the West German regions which received aid irregularly, but not for those which received no aid at all).

In certain cases, predictions for 2004 are unrealistic, being too high or too low, or even negative. For instance, the expenditures per subsidized job in Dresden in 2004 are estimated as -7.72 Ths EUR. This estimate is caused by irregular leaps of Dresden's variable "Aid per job" in 1994–2001, implying a steeply decreasing regression line which after the gap 2002–2003 goes into the negative domain. Such unrealistic predictions are corrected using the technique of **constrained forecast** which limits the predicted values to the range of the preceding observations. The second section of Table 2 contains constrained forecast for three variables from the first section, and, additionally, the regional net unemployment rates derived from constrained predictions of net employed and net unemployed. Thus the negative "Aid per job in 2004" in Dresden is replaced by $+7.81$ Ths EUR which is the minimal value during 1994–2001. The forecast for the regional variables "Productivity" is not constrained, because the development of the regional productivity is quite sustainable and is quasi-linear in all the regions.

The third section of Table 2 contains further derivatives from the constrained forecast 2004 which characterize the efficiency of 1 Mio. EUR aid to the region in 2004 (the 271-vectors with predicted regional figures used further by the model are denoted by boldface letters):

$\boldsymbol{u}$ = net *u*nemployed 2004, in Ths.

$\boldsymbol{n}$ = *n*et unemployment rate 2004 = $\dfrac{\text{Net unemployed 2004}}{\text{Net employed 2004 + Net unemployed 2004}} \cdot 100\%$,

$\boldsymbol{j}$ = 1/Aid per job 2004, in Ths, the additional *j*obs in the region which can be subsidized in 2004 for 1 Mio EUR.

$\boldsymbol{g}$ = Productivity 2004.$*\boldsymbol{j}$, in Mio EUR, the GDP *g*ain in 2004 due to the additional jobs subsidized for 1 Mio. EUR under the expected regional productivity; $.*$ denotes the element-by-element product of two vectors, e.g. $(1,2).*(3,4) = (3,8)$.

$\boldsymbol{d}$ = $\boldsymbol{j}$./(Net employed 2004 + Net unemployed 2004) $\cdot$ 100%, the *d*ecrement in regional unemployment rate 2004 due to the additional jobs subsidized for 1 Mio. EUR; ./ denotes the element-by-element division of two vectors, e.g. $(1,2)./(3,4) = (1/3, 2/4)$.

Target variables Introduce the following notation.

$\boldsymbol{x}$ the (unknown) 271-vector of subsidies to the regions in 2004, in Mio EUR,

$t_1(\boldsymbol{x}) = \boldsymbol{j}'\boldsymbol{x}$ the first target index, the total additional number of jobs in 2004 due to the subsidies $\boldsymbol{x}$; here $'$ denotes the operation of vector/matrix transpose, and $\boldsymbol{j}'\boldsymbol{x}$ is the scalar product of two vectors,

$t_2(\boldsymbol{x}) = \boldsymbol{g}'\boldsymbol{x}$ the second target index, the total increment in the national GDP 2004, in Mio EUR, due to the jobs created for regional subsidies $\boldsymbol{x}$,

$\boldsymbol{n} - \boldsymbol{D}\boldsymbol{x}$ the 271-vector of regional unemployment rates, in %, attainable in 2004 due to subsidies $\boldsymbol{x}$; here $\boldsymbol{n}$ is the predicted net unemployment and $\boldsymbol{D} = \text{diag}\boldsymbol{d}$ is the diagonal matrix with elements of vector $\boldsymbol{d}$ on its main diagonal (decrements in regional unemployment rates due to 1 Mio. EUR aid).

Table 2: 2004-forecast for East German regions and optimal aid distribution

Nr.	Region	Econometric forecast 2004				Constrained forecast 2004				Efficiency of 1 Mio.EUR aid			Separate budgets of East and West			
		Net employed (no aid)	Net unemployed (no aid)	Productivity	Aid pro job	Net employed (no aid)	$\boldsymbol{u}$ Net unemployed (no aid)	$\boldsymbol{n}$ Net unemployment rate	Aid pro job	$\boldsymbol{j}$ Additional jobs	$\boldsymbol{g}$ GDP gain	$\boldsymbol{d}$ Decrement in unemployment rate	$\boldsymbol{x}_{1:0:0}$ Aid distribution w.r.t. employment	$\boldsymbol{x}_{0:1:0}$ Aid distribution w.r.t. GDP	$\boldsymbol{x}_{0:0:1}$ Aid distribution w.r.t. equalization	$\boldsymbol{x}_{2:1:7}$ Aid distribution with Target ratio 2:1:7
		Ths	Ths	Ths.EUR	Ths.EUR	Ths	Ths	%	Ths.EUR	Ths	Mio.EUR	%	Mio.EUR	Mio.EUR	Mio.EUR	Mio.EUR
205	Pasewalk	30.92	11.75	38.9	16.94	31.84	10.77	25.28	16.94	0.059	2.3	0.14			37.68	37.71
206	Greifswald	68.71	19.68	38.4	15.37	68.71	17.75	20.53	19.79	0.051	1.9	0.06				
207	Stralsund	72.14	21.56	38.4	5.70	72.14	19.56	21.33	20.14	0.050	1.9	0.05			7.00	
208	Bergen	30.07	8.28	36.1	37.76	30.07	7.73	20.45	37.76	0.026	1.0	0.07				
209	Neubrandenburg	109.74	35.43	41.2	20.82	109.74	30.82	21.93	20.82	0.048	2.0	0.03			3.60	
210	Waren	27.04	9.47	40.3	3.00	27.04	8.13	23.10	6.55	0.153	6.1	0.43	53.24	53.24	7.92	11.87
211	Güstrow	40.05	14.13	47.7	13.32	40.44	12.45	23.54	13.32	0.075	3.6	0.14			24.62	31.38
212	Rostock	140.59	31.45	50.2	13.55	145.21	31.44	17.80	13.55	0.074	3.7	0.04				
213	Wismar	57.58	17.20	43.9	20.28	57.58	16.40	22.17	20.28	0.049	2.2	0.07			22.43	3.49
214	Schwerin	105.09	22.11	44.1	2.17	109.52	20.05	15.47	8.79	0.114	5.0	0.09				
215	Parchim	38.40	11.62	41.8	−2.18	38.40	10.24	21.05	4.83	0.207	8.7	0.43	49.42	49.42	3.23	9.29
216	Berlin	1866.89	410.67	49.1	12.66	1882.46	355.28	15.88	12.66	0.079	3.9	0.00				348.92
217	Brandenburg a.d. Havel	51.48	17.05	42.1	35.88	52.96	16.13	23.35	35.88	0.028	1.2	0.04			47.00	
218	Belzig	33.02	6.55	42.5	−11.35	31.43	5.53	14.96	6.10	0.164	7.0	0.44	33.73	33.73		
219	Cottbus	145.30	38.21	48.9	19.40	146.80	32.65	18.20	19.40	0.052	2.5	0.03				
220	Eberswalde	29.47	9.13	42.4	8.71	29.47	7.79	20.89	10.58	0.095	4.0	0.25			4.33	8.94
221	Prenzlau	54.07	20.72	49.9	54.49	54.95	19.14	25.83	54.49	0.018	0.9	0.02			127.00	
222	Finsterwalde	44.48	18.18	42.9	6.44	44.48	15.46	25.80	7.84	0.128	5.5	0.21		121.21	27.90	38.74
223	Frankfurt/Oder	141.05	35.67	45.4	8.96	141.05	32.27	18.62	8.96	0.112	5.1	0.06				46.03
224	Luckenwalde	31.27	8.76	56.8	9.68	30.19	7.50	19.90	9.68	0.103	5.9	0.27		72.64	0.46	6.33
225	Neuruppin	64.02	18.69	43.3	17.97	62.49	16.55	20.94	17.97	0.056	2.4	0.07			4.73	
226	Perleberg	31.67	11.39	43.9	9.63	34.36	11.15	24.51	9.74	0.103	4.5	0.23			20.72	27.46
227	Senftenberg	43.28	22.20	41.2	40.89	50.27	19.19	27.63	40.89	0.024	1.0	0.04			167.31	
228	Salzwedel	35.02	10.05	45.0	36.56	35.38	9.71	21.54	36.56	0.027	1.2	0.06			12.39	
229	Stendal	48.20	17.07	44.8	32.53	50.90	16.11	24.04	32.53	0.031	1.4	0.05			61.70	
230	Burg	40.08	12.30	43.7	16.12	40.08	10.91	21.39	16.12	0.062	2.7	0.12			10.32	12.06
231	Magdeburg	198.84	48.89	44.9	39.69	198.84	48.89	19.73	39.69	0.025	1.1	0.01				
232	Halberstadt	92.84	31.52	44.1	36.89	93.78	29.75	24.08	36.89	0.027	1.2	0.02			44.93	
233	Staßfurt	33.04	14.79	49.6	17.38	35.32	13.69	27.93	17.38	0.058	2.9	0.12			66.17	67.09
234	Schönebeck	46.58	17.80	45.1	46.44	48.96	17.80	26.66	46.44	0.022	1.0	0.03			146.15	
235	Dessau	87.81	28.68	42.8	17.88	88.02	27.44	23.77	17.88	0.056	2.4	0.05			54.63	31.75
236	Wittenberg	43.00	16.17	44.3	28.09	45.62	14.71	24.38	28.09	0.036	1.6	0.06			60.21	9.70
237	Sangerhausen	54.96	22.92	43.4	28.99	57.30	20.96	26.78	28.99	0.034	1.5	0.04			124.77	25.77
238	Halle	152.41	42.44	42.2	25.21	158.97	35.35	18.19	25.21	0.040	1.7	0.02				

Table 2: 2004-forecast for East German regions and optimal aid distribution (continued)

Nr. Region	Econometric forecast 2004				Constrained forecast 2004				Efficiency of 1 Mio.EUR aid			Separate budgets of East and West			
						$\boldsymbol{u}$	$\boldsymbol{n}$		$\boldsymbol{j}$	$\boldsymbol{g}$	$\boldsymbol{d}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$
	Net employed (no aid)	Net unemployed (no aid)	Productivity	Aid pro job	Net employed (no aid)	Net unemployed (no aid)	Net unemployment rate	Aid pro job	Additional jobs	GDP gain	Decrement in unemployment rate	Aid distribution w.r.t. employment	Aid distribution w.r.t. GDP	Aid distribution w.r.t. equalization	Aid distribution with Target ratio 2:1:7
	Ths	Ths	Ths.EUR	Ths.EUR	Ths	Ths	%	Ths.EUR	Ths	Mio.EUR	%	Mio.EUR	Mio.EUR	Mio.EUR	Mio.EUR
239 Bitterfeld	28.26	16.88	51.5	71.61	37.17	15.24	29.08	71.61	0.014	0.7	0.03			248.46	
240 Naumburg	133.04	48.52	49.1	22.43	135.90	42.14	23.67	22.43	0.045	2.2	0.03			40.75	
241 Erfurt	165.04	29.76	41.7	12.64	165.04	28.51	14.73	12.64	0.079	3.3	0.04				
242 Weimar	67.29	14.45	35.9	−1.33	66.67	13.40	16.74	6.75	0.148	5.3	0.18	90.52	90.52		
243 Gera	99.35	24.55	39.8	10.72	101.12	24.55	19.53	10.72	0.093	3.7	0.07				19.74
244 Jena	98.74	15.99	44.5	19.53	95.59	15.99	14.33	19.53	0.051	2.3	0.05				
245 Suhl	50.58	12.13	40.5	5.56	50.58	12.13	19.34	6.04	0.166	6.7	0.26	73.24	73.24		8.94
246 Eichsfeld	44.09	9.80	36.3	9.75	41.63	9.80	19.06	9.75	0.103	3.7	0.20				3.12
247 Nordhausen	37.67	10.65	43.5	4.82	38.38	10.65	21.72	4.98	0.201	8.7	0.41	53.01	53.01	4.98	11.34
248 Eisenach	78.76	16.71	37.2	4.98	78.76	16.71	17.51	7.63	0.131	4.9	0.14	127.45			4.50
249 Mühlhausen	49.48	10.40	37.0	4.46	49.17	10.40	17.46	4.82	0.207	7.7	0.35	50.17	50.17		1.86
250 Sondershausen	32.54	12.28	39.9	8.01	32.54	12.28	27.40	8.01	0.125	5.0	0.28			27.39	33.67
251 Meiningen	62.84	13.89	38.8	7.39	61.46	13.89	18.44	7.46	0.134	5.2	0.18	103.58	53.08		6.95
252 Gotha	64.94	13.18	42.8	6.16	63.68	13.18	17.15	8.37	0.120	5.1	0.16				
253 Arnstadt	46.77	13.09	38.5	9.97	45.78	13.09	22.24	9.97	0.100	3.9	0.17			13.42	22.76
254 Sonneberg	27.24	4.66	37.6	9.57	26.35	4.66	15.03	9.57	0.104	3.9	0.34				
255 Saalfeld	49.26	12.68	43.0	0.15	50.28	12.68	20.14	5.40	0.185	8.0	0.29	68.53	68.53	1.31	11.75
256 Pö	41.55	10.37	41.2	−0.19	41.55	10.25	19.80	4.99	0.201	8.3	0.39	51.14	51.14	0.27	7.15
257 Altenburg	39.58	14.67	39.7	8.38	39.58	13.58	25.55	8.38	0.119	4.7	0.22			25.43	33.84
258 Leipzig	365.37	88.34	40.9	18.60	365.37	76.27	17.27	18.60	0.054	2.2	0.01				
259 Torgau/Oschatz	68.64	21.67	40.6	6.18	68.64	19.91	22.49	7.99	0.125	5.1	0.14			17.27	38.45
260 Grimma	50.95	15.69	41.8	7.67	50.12	12.88	20.44	8.27	0.121	5.1	0.19			2.83	14.52
261 Freiberg	87.50	29.38	38.1	8.58	89.04	26.64	23.03	9.40	0.106	4.1	0.09			29.21	60.67
262 Chemnitz	236.48	61.16	41.9	4.87	246.40	56.67	18.70	6.54	0.153	6.4	0.05	370.64	370.64		173.93
263 Annaberg	116.22	38.16	36.4	7.71	116.22	35.15	23.22	8.77	0.114	4.1	0.08			35.65	87.51
264 Zwickau	108.17	29.15	44.4	12.39	107.92	26.56	19.75	12.39	0.081	3.6	0.06				14.97
265 Plauen	109.04	28.66	39.2	7.81	109.04	26.34	19.46	7.81	0.128	5.0	0.09	15.90			36.44
266 Dresden	341.10	63.01	43.8	−7.72	341.10	55.52	14.00	6.31	0.158	6.9	0.04	350.35	350.35		193.12
267 Riesa	48.68	14.48	43.3	22.62	48.68	14.17	22.54	22.62	0.044	1.9	0.07			27.47	3.93
268 Pirna	104.90	31.20	34.1	1.97	104.90	26.93	20.43	6.03	0.166	5.7	0.13	162.45	162.45	2.47	41.39
269 Bautzen	147.62	47.54	40.1	12.75	147.62	40.67	21.60	12.75	0.078	3.1	0.04			5.13	48.77
270 Görlitz	62.88	22.16	34.8	17.06	62.88	19.91	24.05	17.06	0.059	2.0	0.07			48.68	38.82
271 Löbau-Zittau	58.53	19.34	34.3	18.72	58.53	17.58	23.10	18.72	0.053	1.8	0.07			35.44	18.73
West Germany	32045.70	2531.20	59.2		31490.37	2520.09	7.41					282.66	282.66	282.66	282.66
East Germany	7212.18	1897.13	44.0		7282.40	1717.64	19.08					1653.38	1653.38	1653.38	1653.38
Whole Germany	39257.88	4428.32	56.4		38772.77	4237.73	9.85					1936.04	1936.04	1936.04	1936.04

$t_3(\boldsymbol{x}) = \mathsf{V}(\boldsymbol{n} - \boldsymbol{Dx}) = \frac{1}{m-1}\Big(\boldsymbol{x}'\boldsymbol{DVDx} - 2\boldsymbol{n}'\boldsymbol{VDx} + \boldsymbol{n}'\boldsymbol{Vn}\Big)$, in $\%^2$, the third target index, the variance of m regional unemployment rates attainable in 2004 due to subsidies $\boldsymbol{x}$ which characterizes the *disparity among regions*. The expression for this target index follows from the two propositions below.

Theorem 1 (Variance operator, Theil 1971, p. 12)
Consider a vector of m observations $\boldsymbol{y} = (y_1, \ldots, y_m)$. Then their variance

$$\frac{1}{m-1}\sum_{r=1}^{m}\left(y_r - \frac{1}{m}\sum_{s=1}^{m} y_s\right)^2 = \frac{1}{m-1}\,\|\boldsymbol{Vy}\|^2 \quad , \tag{1}$$

where the variance operator $\boldsymbol{V}$ *is the* $(m \times m)$*-matrix*

$$\boldsymbol{V} = \begin{pmatrix} 1-\frac{1}{m} & -\frac{1}{m} & \ldots & -\frac{1}{m} & -\frac{1}{m} \\ -\frac{1}{m} & 1-\frac{1}{m} & \ldots & -\frac{1}{m} & -\frac{1}{m} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ -\frac{1}{m} & -\frac{1}{m} & \ldots & -\frac{1}{m} & 1-\frac{1}{m} \end{pmatrix} = \begin{pmatrix} 1 & 0 & \ldots & 0 & 0 \\ 0 & 1 & \ldots & 0 & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ 0 & 0 & \ldots & 0 & 1 \end{pmatrix} - \frac{1}{m} \ .$$

The variance matrix is symmetric and idempotent, that is,

$$\begin{aligned} \boldsymbol{V}' &= \boldsymbol{V} \\ \boldsymbol{VV} &= \boldsymbol{V} \ . \end{aligned}$$

Theorem 2 (Unemployment disparity among regions)
The variance of m regional unemployment rates attained due to subsidies $\boldsymbol{x}$ is

$$\mathsf{V}(\boldsymbol{n} - \boldsymbol{Dx}) = \frac{1}{m-1}\Big(\boldsymbol{x}'\boldsymbol{DVDx} - 2\boldsymbol{n}'\boldsymbol{VDx} + \boldsymbol{n}'\boldsymbol{Vn}\Big) \ . \tag{2}$$

PROOF. Substitute $\boldsymbol{y} = \boldsymbol{n} - \boldsymbol{Dx}$ into (1) and obtain:

$$\begin{aligned} \mathsf{V}(\boldsymbol{n} - \boldsymbol{Dx}) &= \frac{1}{m-1}\|\boldsymbol{V}(\boldsymbol{n} - \boldsymbol{Dx})\|^2 \\ &= \frac{1}{m-1}(\boldsymbol{Vn} - \boldsymbol{VDx})'(\boldsymbol{Vn} - \boldsymbol{VDx}) \quad \overset{(AB)'=B'A',\ \boldsymbol{V}'=\boldsymbol{V}}{\Longrightarrow} \\ &= \frac{1}{m-1}(\boldsymbol{n}'\boldsymbol{V} - \boldsymbol{x}'\boldsymbol{DV})(\boldsymbol{Vn} - \boldsymbol{VDx}) \quad \overset{\boldsymbol{VV}=\boldsymbol{V}}{\Longrightarrow} \\ &= \frac{1}{m-1}\Big(\boldsymbol{n}'\boldsymbol{Vn} - \boldsymbol{x}'\boldsymbol{DVn} - \boldsymbol{n}'\boldsymbol{VDx} + \boldsymbol{x}'\boldsymbol{DVDx}\Big) \quad \overset{(AB)'=B'A'}{\Longrightarrow} \\ &= \frac{1}{m-1}\Big(\boldsymbol{x}'\boldsymbol{DVDx} - 2\boldsymbol{n}'\boldsymbol{VDx} + \boldsymbol{n}'\boldsymbol{Vn}\Big) \ . \qquad \blacksquare \end{aligned}$$

Optimal regional policy As mentioned in the Introduction, the subsidies are aimed at reducing regional disparities. Since an increase in total employment and GDP are also desired, we obtain the following proposition.

Theorem 3 (Optimization of regional policy)
Given total budget B, list of the regions eligible to receive subsidies, and importance ratio of three target variables $a : b : c$, then the optimal aid distribution $\boldsymbol{x} = \{x_r\}$ is the solution to the problem

$$\begin{array}{rl} \text{maximize} & at_1(\boldsymbol{x}) + bt_2(\boldsymbol{x}) - ct_3(\boldsymbol{x}) \\ \text{subject to} & \sum_r x_r \leq B \quad \text{(budget constraint)} \\ & \mathbf{0} \leq \boldsymbol{J}\boldsymbol{x} \leq \boldsymbol{u} \quad \text{(fewer jobs than unemployed in the region)} \\ & x_r = 0 \quad \text{for non-eligible regions } r \ , \end{array} \tag{3}$$

where $\boldsymbol{J} = \mathrm{diag}\boldsymbol{j}$ is the diagonal matrix with elements of vector $\boldsymbol{j}$ on its main diagonal. Taking into account the expressions for targets $t_i(\boldsymbol{x})$, we obtain a quadratic programming problem with the objective function

$$at_1(\boldsymbol{x}) + bt_2(\boldsymbol{x}) - ct_3(\boldsymbol{x}) = -\boldsymbol{x}' \left(\frac{c}{m-1} \boldsymbol{D}\boldsymbol{V}\boldsymbol{D} \right) \boldsymbol{x} + \left(2c\boldsymbol{n}'\boldsymbol{V}\boldsymbol{D} + a\boldsymbol{j} + b\boldsymbol{g} \right)' \boldsymbol{x} \tag{4}$$

which Hessian $\boldsymbol{D}\boldsymbol{V}\boldsymbol{D}$ is symmetric implying the problem solvability. (The constant $-c\boldsymbol{n}'\boldsymbol{V}\boldsymbol{n}$ plays no role in the maximization and is omitted in the objective function.)

Notes on the model assumptions One of the critical points of the model is that one cannot subsidize one region without affecting neighboring regions. The regional responses to the aid are cross-correlated, which is ignored in our simplified linear model. Time factors like those considered by Griffith (1996) and Elhorst (2001) are also not taken into account. These and similar properties could be implemented if we dealt exclusively with a prediction model. The situation is complicated by the optimization which operates on the response *equations* (not fixed predictions!).

1. NON-COMPUTABILITY OF A NON-LINEAR MODEL MODEL

   If the linear model of regional response to subsidies $\boldsymbol{n} - \boldsymbol{D}\boldsymbol{x}$ in the variance operator (2) is replaced by a non-linear model, then the quadratic objective function (4) is no longer quadratic. For instance, if cross-correlations between regions are considered then the response model becomes quadratic, and the objective function (4) has the fourth polynomial degree. If, instead of a linear forecast, non-linear time factors are considered, then, again, the degree of the objective function increases.

   Since there are no available computational methods to solve such problems, the alternatives are: an accurate non-computable model or an inaccurate computable model.

2. LINEARITY AS THE FIRST-ORDER APPROXIMATION

   On the other hand, the assumption of the linear regional response to subsidies, both spatial and temporal as in our case, can be regarded as the first-order approximation of the unknown response function. This general interpretation follows from the Taylor expansion of a function up to the first term: It is the first-order approximation of the function, and it is linear in the argument increment.

In particular, it implies that the error increases as the model variables deviate from the initial values. Therefore, 'moderate' solutions with a strong impact of the equalization target are more accurate than 'extreme' solutions which neglect the equalization. It is an additional argument for the controllability of an economy with a well-equalized regional unemployment.

If necessary the model (3) can be easily upgraded with additional constraints, like the bottom unemployment limit 2% instead of 0% and specific restrictions for particular regions, or with weights to favor priority regions.

Normalizing targets and their weights The weights a, b, c reflect no relative importance of targets because of their different range:

t_1 (Additional jobs): 50–500 Ths,

t_2 (GDP gain): 6–17 Bio EUR, and

t_3 (Variance of regional unemployment): 3–40%^{2}.

For instance, equal target weights $a = b = c$ imply no equal priorities but the absolute predominance of target t_2 and neglect of targets t_1 and t_3. Therefore, we normalize the target variables $t = t_1, t_2, t_3$ by reducing their ranges to 0–1:

$$\begin{aligned} t_{\text{normal}} &= \frac{t - t_{\min}}{t_{\max} - t_{\min}} \\ t &= t_{\text{normal}}\Big(t_{\max} - t_{\min}\Big) + t_{\min} \end{aligned}$$

The target limits are obtained from solving three one-target problems (with all the weights but one equal to 0). For instance, putting $a = b = 0, c = 1$ we obtain the problem for equalizing regional unemployment rates regardless of the other two target variables. Since all the resources are channelled to attaining this goal, one attains the maximum possible value $t_{3\,\max}$.

From now on we refer to normalized weights of target variables. For instance, it is the case of weight ratios 2 : 1 : 7 in Table 2.

3 Analysis of the past practice

Recall that the grant discussed is given primarily to equalize the regional unemployment rates. The budgets of West and East parts are separate, meaning that there are in fact two equalization programs. What was done actually and what could be done with the optimization model?

Better results for the same budget To be specific, consider East Germany in 2000–2002. During this three-year period it received both national and European subsidies for equalization of regional unemployment rates. Apply model (3) to East German regions 205–271. Put target weights $a = b = 0, c = 1$, meaning that the attention is restricted to the goal of the grant, equalization of regional unemployment, ignoring side goals. The

Table 3: Efficiency of the actual equalization programs in 2000–2002

	Actual state 2002			Optimal equalization		Budget optimization			Efficiency
	Average unemployment rate	Variance	Actual budget	Average unemployment rate	Variance	Average unemployment rate	Variance	Sufficient budget	Sufficient-to-actual budget ratio
	%	$\%^2$	Bio.EUR	%	$\%^2$	%	$\%^2$	Bio.EUR	%
West Germany	7.45	4.40	0.62	7.28	3.50	7.48	4.40	0.24	39.1
East Germany	18.21	9.76	5.36	18.21	0.28	22.93	9.17	0.00	0.0
Whole of Germany	10.11	27.29	5.98	9.49	17.32	10.25	27.29	3.01	51.8

total budget is $B = 5.36$ Bio.EUR. The last constraint in (3) is omitted, because all East German regions are eligible to receive the aid.

The top two graphs in Figure 1 displays the actual situation in East Germany in 2000 and in 2002 after the three-year equalization program has been implemented. The horizontal axis shows the East German regions numbered from 205 to 271. The vertical axis shows the regional unemployment rate in %. The (unweighted) average regional unemployment rate for East Germany is traced by the horizontal line. The variance of regional unemployment is illustrated by deviations from the mean.

In three years, neither the average regional unemployment rate, nor the variance are reduced. On the contrary, both indices grow (the average 17.68 $\nearrow$ 18.21%, and the variance 8.91 $\nearrow$ 9.76$\%^2$). This outcome is due to two factors, unfavorable economic development and bad management of the equalization program. To separate the effects, consider the third graph in Figure 1 with the situation in 2002 if no jobs were subsidized (= net regional unemployment rates). Naturally, the average unemployment is higher because of fewer jobs. However, the variance of net regional rates, as if with no subsidies, is *smaller* than with the subsidies. It means that the equalization program makes more harm than good and aggravates the economic development by investing money in *wrong* regions.

The bottom graph in Figure 1 shows which equalization could be attained in East Germany for the same budget. Instead of 8.91 $\nearrow$ 9.76$\%^2$, the variance can be drastically reduced to $\searrow$ 0.28$\%^2$, meaning an almost perfect equalization of regional unemployment rates. It does not even affect the average unemployment, retaining it at the same 18.21%. This effect is only due to channelling money to the *right* regions in the *right* proportion.

The actual and optimal figures, in particular for East Germany, are collected in the first two sections of Table 3. The goal of the subsidies, the equalization, is shown by the normal font; the auxiliary average unemployment is shown by a small font.

What is wrong with the actual budget distribution? For instance, consider Berlin (the region No. 216). Its *net* unemployment rate (with no subsidies) 18.7% is almost equal to the East German average 18.21%, meaning no urgency in subsidies. Nevertheless Berlin gets the most, 536.7 Mio. EUR, which brings its unemployment rate down to 16.6%. Thereby the initial deviation from the average 0.49% is tripled and becomes 1.61%. Besides, due to a large population, reducing Berlin's unemployment by one percent is much more costly for grant-givers than that in small regions. It means that half Bio.EUR

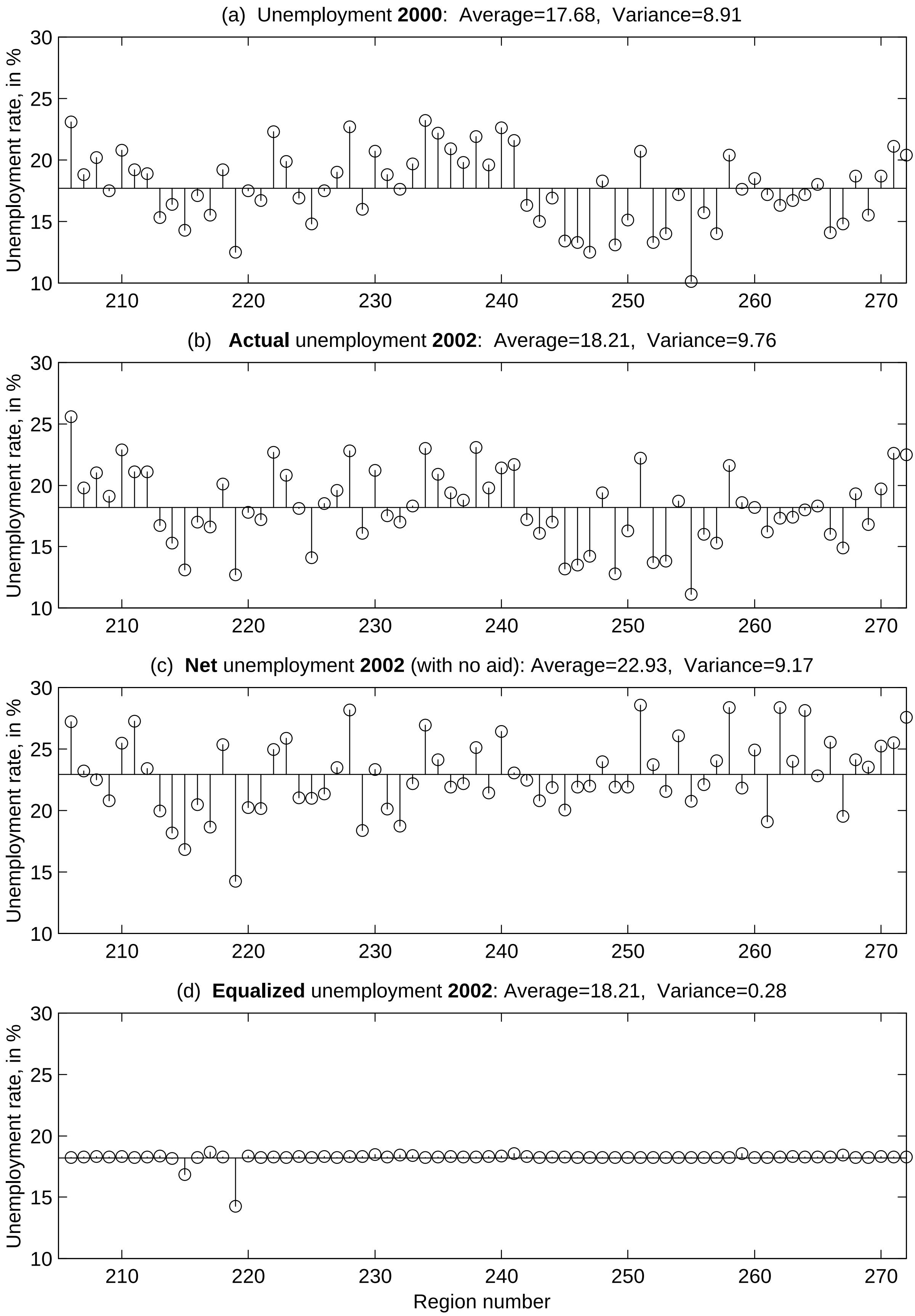

Figure 1: Equalization of unemployment in **East** Germany (regions 205–271)

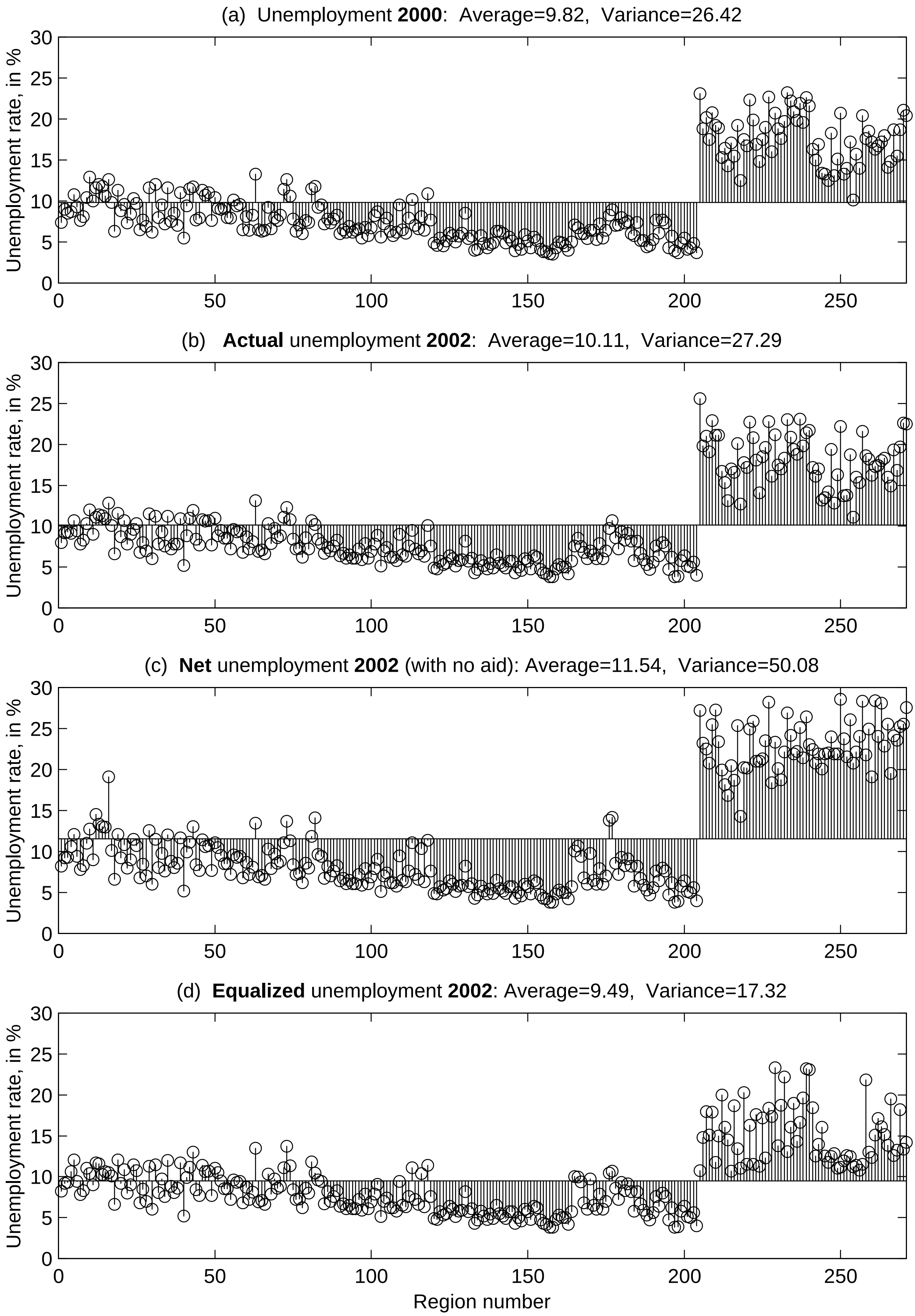

Figure 2: Equalization of unemployment in the **whole** of Germany (regions 1–271)

unnecessarily and irrationally spent for Berlin could be used for other regions with much greater urgency and with much higher efficiency.

Such planning errors are typical for large towns. For example, Dresden, Magdeburg, Jena, Wismar, Schwerin, Rostock receive two-three times more subsidies than necessary but other regions are strong undersubsidized, e.g., Naumburg by 277 Mio.EUR, Stendal by 179 Mio.EUR, Bitterfeld by 118 Mio.EUR, etc.

The situation in West Germany is similar, although less salient. The West German budget is eight times lower, and the number of regions is three times higher than in East Germany. Besides, not all West German regions are eligible to receive the aid. The additional constraints reduce the feasible domain for optimization, making it less effective.

In case of West Germany, model (3) is applied to regions 1–204. The target weights $a = b = 0, c = 1$, and the budget $B = 617.8$ Mio.EUR. The last constraint in (3) is not omitted. For exact results of optimization see Table 3.

Better results due to a joint East-West budget As general in optimization, the fewer constraints, the larger the feasible domain and the larger the range of attainable values of the objective function. In our case, considering a joint budget of both East and West Germany allows to obtain better equalization results under the same total budget.

Therefore, model (3) is applied to regions 1–271 with target weights $a = b = 0, c = 1$ and the joint budget $B = 5.98$ Bio.EUR. The last constraint in (3) is as in the model for West Germany, since all East German regions are eligible. The optimization results are displayed in Figure 2 with the same design as Figure1. In spite of 5.98 Bio.EUR subsidies during 2000–2002 both indices of regional unemployment increased: the average all-Germany rate 9.82 $\nearrow$ 10.11%, and the all-German variance 26.42 $\nearrow$ 27.29%^{2}. At the same time, a joint budget would reduce both indicators: 9.82 $\searrow$ 9.49% for the average rate, and 26.42 $\searrow$ 17.32%^{2} for the variance.

For comparing actual and optimal results see the last row in the first two sections of Table 3.

Equal results for a lower budget (budget optimization) The efficiency of a decision is the fraction of its budget which is sufficient to attain the same results. Say, if the actual equalization of unemployment could be attained with 20% of the actual budget, then the efficiency of the actual program is 20%.

The third section of Table 3 displays which budget suffices to attain the actual equalization. To find the minimal sufficient budget, model (3) is applied to progressively lower budget unless the optimized variance is equal to the actual variance in 2002.

As seen from Table 3 for West Germany, 0.24 Bio.EUR of actual 0.62 Bio.EUR suffices to attain the actual variance 4.40%^{2}, meaning the 39%-efficiency of the actual equalization program displayed in the right-hand column of Table 3.

The equalization program in East Germany only increased the disparity among regions. No subsidy would imply a lower variance than the actual one, meaning the 0%-efficiency of the actual equalization program.

Thus, the equalization in East and West Germany actually made for 5.98 Bio.EUR could be attained for only 0.24 Bio.EUR, meaning **the total 4%-efficiency of both programs together**.

From the viewpoint of the hypothetical joint East-West budget the situation is somewhat different. The efficiency of the actual program is almost 52%. Note that the total efficiency is much higher than that of each contributing program. It is explained as follows.

The all-German average regional unemployment rate in 2002 is 10.11% which is much lower than the East German average 18.21%. The subsidies to East German regions are often superfluous and miss to bring the regional unemployment rates to the East German average but nevertheless reduce their distance to the much lower all-German level. Therefore, from the all-German viewpoint, the grant to East Germany is not used that irrationally as it looks from the East German viewpoint.

Summary of the analysis of the past practice The implementation of actual governmental programs for equalizing regional unemployment rates is far from being optimal, both in East and West Germany. There are at least three directions for improvements:

1. Optimizing the equalization program for the given budget.
2. Optimizing the shares of West and East Germany in the total budget.
3. Optimizing the program for a fraction of the initial budget and releasing some resources for side goals like reducing the national unemployment and/or subsidizing competitive industries.

4 Managing regional policy

The three directions for improvements are previewed in model (3) by allowing variable number of regions, variable target weights and variable budget. Let us describe how to design the regional policy for 2004.

One-target and three-target optimization The fourth section of Table 2, 'Separate budgets of East and West' contains four East German optimal budget allocations found by model (3) for three one-target and one combined policy. Figure 3 displays the effects of four optimal policies both for West Germany, whose regions 1–204 are depicted in blue, and for East Germany, whose regions 205–271 are depicted in red, under the assumption that they have separate budgets.

To be specific, consider East Germany (depicted in red). Its budget $B = 1653.38$ Mio EUR for 2004 is predicted from years 1994–2001, when it gradually decreased. All the $m = 67$ East German regions numbered 205–271 were eligible to receive the aid, which we accept for the year 2004 in (3).

The predicted **net regional unemployment rates** (with no aid) are shown in plots of Figure 3 by the stair contour. The colored bars show the **unemployment rates reduced** due to the optimal aid received. The residual white gaps between the stair contour and colored bars depict the proper **effect of the aid**. Let us comment on each policy in some detail.

- Employment-only policy, or maximization of additional jobs, the target weight ratio 1 : 0 : 0.

  The model exhausts the unemployment in the 15 of 67 regions with the most 'cheap'

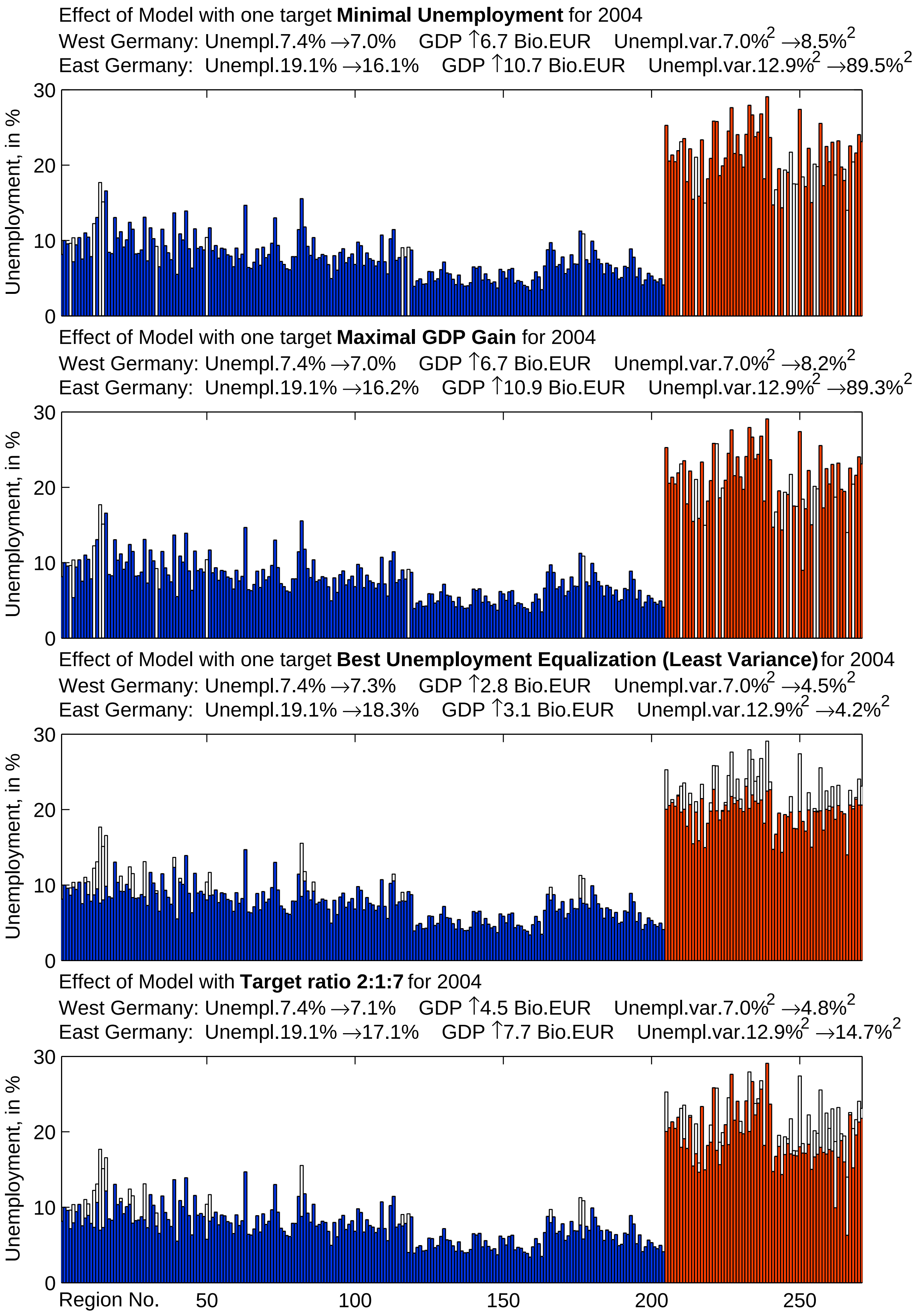

Figure 3: Effects of aid distribution with a separate budget for West and East Germany

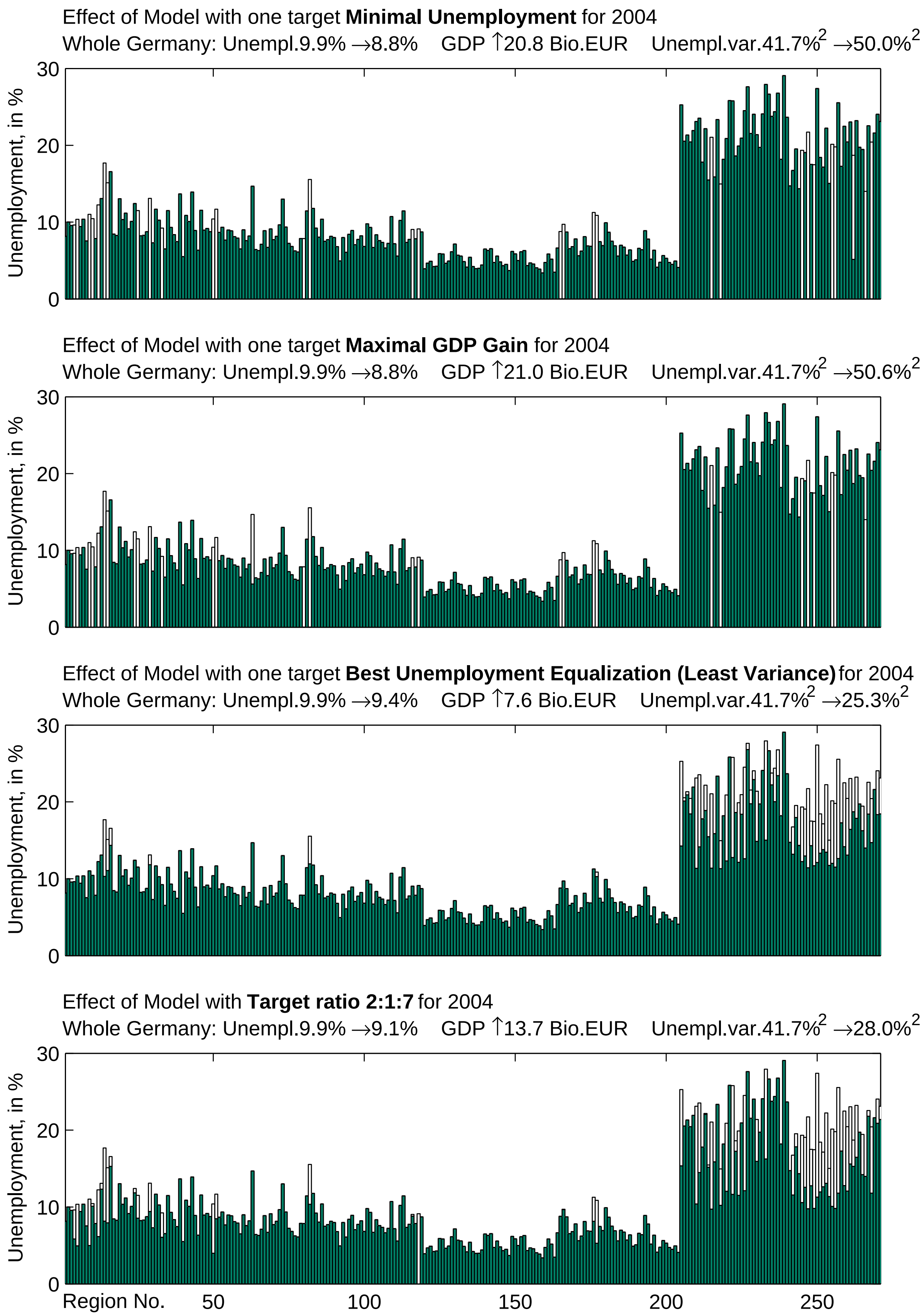

Figure 4: Effects of aid distribution with a joint budget for West and East Germany

jobs, including, among others, Wiemar, Eisenach, Chemniz, and Dresden. The last subsidized region is 265 (Plauen) where the aid efficiency is as low as 134 jobs for 1 Mio EUR aid. Here, the almost exhausted aid suffices to subsidize only a few jobs, resulting in a small white gap in the upper plot.

This policy reduces the predicted average unemployment by 3%, increases the predicted GDP by almost 11 Bio EUR, but compared to the predicted net value, increases the unemployment variance $12.9 \nearrow 90\%^2$.

- GDP-MAXIMIZATION-ONLY POLICY, or competitiveness-supporting policy, the target weight ratio 0 : 1 : 0.

  The model also selects 15 of 67 regions, but now with the best productivity-to-'job-price' ratio. The last subsidized region is 251 (Meiningen) with the aid efficiency as low as 5.2 Mio EUR of GDP gain from 1 Mio EUR aid (520%-returns).

  Compared to the previous case, the policy results in a little higher GDP gain (by only 135 Mio EUR) and a little higher average unemployment (by 0.1%). The unemployment variance is almost the same, being $0.2\%^2$ lower. 13 of the 15 regions selected coincide in both policies.

  This means that **productive regions are 'cheap' for grant-givers**. Highly competitive industries can create new jobs with little aid.

- EQUALIZATION-ONLY POLICY, or least variance of regional unemployment rates, the target weight ratio 0 : 0 : 1.

  The model selects 41 of 67 regions with a high net unemployment (vector $\boldsymbol{n}$) which reduction is still affordable (vector $\boldsymbol{d}$). The effect of the policy can be well seen in the third plot of Figure 3.

  The available aid significantly reduces the unemployment variance $12.9 \searrow 4.2\%^2$, but the average unemployment decreases by only 0.8% and the increment in GDP is as low as 3.1 Bio.EUR (188%-return from the aid).

- COMBINED THREE-TARGET POLICY, with the target weight ratio 2 : 1 : 7.

  The effect of this policy is shown in the bottom plot of Figure 3. Compared to the equalization-only policy, it suggests 2.5 times higher increment in GDP (7.7 instead of 3.1 Bio.EUR) and 2.5 times greater decrement in the national unemployment (2.0 instead of 0.8%). However, compared to the predicted net value, the disparity among regions somewhat increases ($12.9 \nearrow 14.7\%^2$ instead of $12.9 \searrow 4.2\%^2$), although it is far from $90\%^2$ as under the employment-only and competitiveness-only policies.

  An increase in the regional disparity does not meet the main destination of the aid. Adjusting the target weight ratio, for instance, to 2:0.5:7.5 (not illustrated by a plot), we obtain the (optimized) policy with the unemployment variance $12.9 \searrow 11.7\%^2$. If necessary, the equalization can be more emphasized by giving more weight to the third target.

The cases of West Germany (shown by blue in Figure 3), as well as of the whole of Germany with a joint budget (shown by green in Figure 4) are analogous. The main numeric specifications of the alternative policies can be found in captions to plots, and we do not comment on them here.

Triangle of priorities and target maps The target weight ratio $a : b : c$ in model (3) says little to a policy maker. In fact, the only points of interest are the attainable combinations of national unemployment, GDP gain, and variance of regional unemployment rates. The one-to-one correspondence between target weight ratios and optimal solutions can be used to build a simple user interface to the model. Instead of operating on weight ratios, the policy maker can make choices directly from triplets of optimized target indices.

This idea is implemented in the *triangle of priorities* in Table 4 which displays the triplets of indices optimized for target weights in 0.1 steps. For this purpose, the target weights $a, b, c \geq 0$ are normalized to $a + b + c = 1$ which determine the triangular form of the table. For instance, the cell with target weights 0.2 : 0.1 : 0.7 lies at the intersection of the column indexed 0.1 and row indexed 0.7. The cells with weights of the first target 0.2 lie at the diagonal indicated by an arrow stemming from 0.2 in the foot row of the table.

Consider the head element in the table cells, the national unemployment, as the height over the plane. The resulting 'relief' is depicted in the upper row of Figure 5 both as a target map and as its three-dimensional relief.

The middle elements in the table cells, GDP gain, constitutes another relief on the same triangle of priorities. Its map and the relief itself are depicted in the middle section of 5. Similarly, the bottom section of Figure 5 show the map and the relief of the foot element of the table cells.

The maps and reliefs in Figure 5 illustrate the triple effect of moving within the triangle of priorities. For instance, moving towards the vertex 'Employment' implies a decrease in the unemployment (upper relief), increase in GDP (middle relief) but an increase of the unemployment variance (bottom relief).

The specific particularity of all the three reliefs is that their isolines are almost parallel to the first axis. It means that in the space of optimal policies, both targets, 'maximization of employment' and 'maximization of GDP', are operationally highly correlated. In other words, subsidizing 'cheap' jobs leads to supporting most competitive industries and vice versa.

We conclude that the three-dimensional **policy space can be reduced to two-dimensions**, with 'maximization of employment' and 'maximization of GDP' merging into one factor.

Flexibilizing the budget Political decisions are often made with a certain budget flexibility. Depending on the effects expected, the initially intended budget can be somewhat increased or reduced.

The model discussed can predict the triplets of target indices for variable budgets, enabling to trace the effect-to-budget ratio. The task is simplified due to a high correlation of the 'Employment' and 'GDP' target indices. Therefore, it suffices to consider variable budgets only for the target weight ratios 'Employment : Equalization'.

Consider normalized target weight ratios $a : c$, $a + c = 1$, $a \geq 0$, $c \geq 0$. Since c uniquely determines a, the variety of weight ratios is one-dimensional. It allows to represent variable target ratios versus variable budgets by a two-dimensional Table 5. The vertical dimension, 'Equalization priority' shows the weight c in 0.05 steps (then $a = 1 - c$). The horizontal dimension shows the hypothetical budget for the East German regional policy 2004. Every cell of the table contains four elements. The first three are

Table 4: Unemployment, in %
GDP gain, in Mio EUR
Unemployment variance, in $\%^2$ optimized on the triangle of priorities for East Germany 2004

Equalization	GDP priority										
priority	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
1	18.3 3112 4.2										
0.9	18.0 3909 4.8	18.1 3897 4.8									
0.8	17.6 5658 8.3	17.5 6157 9.1	17.5 6497 9.9								
0.7	17.0 7594 15.1	17.1 7672 14.7	17.1 7722 14.5	17.2 7698 14.3							
0.6	16.7 8870 22.4	16.7 8930 22.6	16.7 8931 22.4	16.8 8856 21.5	16.8 8745 20.6						
0.5	16.6 9402 27.1	16.6 9414 27.0	16.6 9426 26.9	16.6 9438 26.9	16.6 9450 27.0	16.6 9462 27.1					
0.4	16.5 9730 32.2	16.5 9733 31.8	16.5 9735 31.4	16.5 9737 31.2	16.5 9738 31.0	16.5 9739 30.9	16.5 9739 30.8				
0.3	16.4 9991 38.7	16.4 10004 38.3	16.4 10018 38.0	16.4 10031 37.7	16.4 10045 37.6	16.4 10058 37.6	16.4 10072 37.8	16.4 10081 38.0			
0.2	16.3 10381 52.4	16.3 10402 52.7	16.2 10425 53.0	16.3 10447 53.0	16.3 10451 52.4	16.3 10449 51.5	16.3 10445 50.7	16.3 10441 50.2	16.3 10436 49.9		
0.1	16.2 10713 71.4	16.2 10716 70.9	16.2 10719 70.5	16.2 10722 70.2	16.2 10729 69.8	16.2 10739 69.5	16.2 10748 69.5	16.2 10758 69.7	16.2 10763 69.8	16.2 10764 69.6	
0	16.1 10747 89.5	16.1 10754 88.9	16.1 10817 88.6	16.1 10817 88.6	16.1 10817 88.6	16.1 10820 88.4	16.1 10839 88.5	16.2 10872 89.3	16.2 10872 89.3	16.2 10872 89.3	16.2 10872 89.3
Employment priority	↖ 1	↖ 0.9	↖ 0.8	↖ 0.7	↖ 0.6	↖ 0.5	↖ 0.4	↖ 0.3	↖ 0.2	↖ 0.1	↖ 0

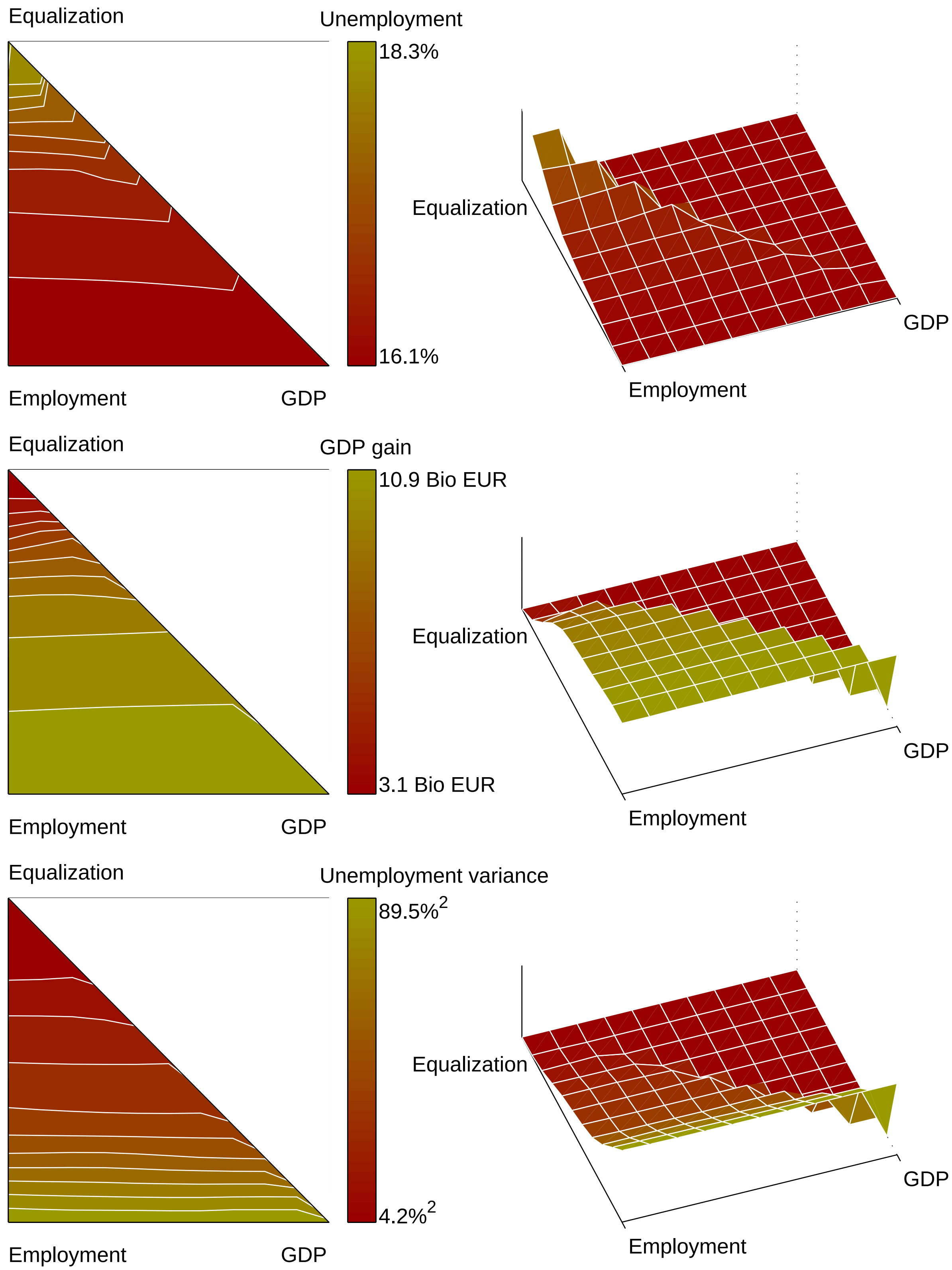

Figure 5: The triangle of priorities with maps and reliefs of three target variables optimized for East Germany 2004

Table 5:

Unemployment, in %
GDP gain, in Mio EUR
Unemployment variance, in $\%^2$
Profitability, in %

under variable budget for East Germany 2004

Equalization Priority	Investment in regional policy, in Mio EUR: 0	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000
1	19.1	18.1	17.0	15.8	14.5	14.0	14.0	14.0	14.0	14.0	14.0
	0	3767	7948	12403	17595	19679	19679	19679	19679	19679	19679
	12.9	3.4	0.9	0.2	0.0	−0.0	−0.0	−0.0	−0.0	−0.0	−0.0
		−26.4	−22.3	−19.2	−14.0	−23.1	−35.9	−45.0	−51.9	−57.3	−61.5
0.95	19.1	18.0	16.8	15.4	14.0	12.6	11.1	9.7	8.3	6.9	5.5
	0	4084	8626	14371	20103	25744	31353	36963	42572	48182	53792
	12.9	3.5	1.1	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
		−20.2	−15.7	−6.3	−1.7	0.7	2.2	3.2	4.0	4.7	5.2
0.9	19.1	17.8	16.5	14.9	13.4	11.9	10.5	9.1	7.7	6.3	4.9
	0	4690	9923	16382	22591	28574	34204	39814	45423	51033	56458
	12.9	4.1	2.1	2.1	2.3	2.6	2.6	2.6	2.6	2.6	2.5
		−8.3	−3.0	6.8	10.4	11.7	11.4	11.2	11.0	10.9	10.4
0.85	19.1	17.6	16.1	14.5	12.9	11.4	9.9	8.4	7.1	5.7	4.4
	0	5476	11824	18329	24750	30874	36816	42735	48026	53060	58059
	12.9	5.4	4.6	4.6	5.1	5.5	5.9	6.3	6.0	5.5	5.0
		7.1	15.6	19.4	21.0	20.7	20.0	19.4	17.4	15.3	13.5
0.8	19.1	17.3	15.6	14.0	12.5	10.9	9.4	8.0	6.7	5.3	4.1
	0	6874	13810	20472	26944	33276	38966	44253	49540	54619	59342
	12.9	8.3	8.5	8.8	9.3	10.0	10.0	9.7	9.5	9.1	8.0
		34.4	35.0	33.4	31.7	30.1	27.0	23.6	21.1	18.6	16.0
0.75	19.1	17.0	15.2	13.6	11.9	10.4	9.0	7.6	6.3	5.0	3.8
	0	8122	15491	22406	29266	35175	40581	45723	50755	55628	60500
	12.9	11.9	13.1	14.0	15.4	15.5	15.2	14.3	13.4	12.4	11.8
		58.8	51.4	46.0	43.0	37.5	32.2	27.7	24.0	20.8	18.3
0.7	19.1	16.7	14.9	13.2	11.5	10.0	8.6	7.3	6.0	4.7	3.5
	0	8936	16566	24063	31112	36823	42019	46981	51853	56726	61533
	12.9	15.4	17.3	20.0	22.2	22.3	21.2	19.6	18.1	17.1	16.2
		74.7	61.9	56.8	52.1	44.0	36.9	31.2	26.7	23.2	20.3
0.65	19.1	16.5	14.7	12.9	11.1	9.6	8.2	6.9	5.7	4.4	3.2
	0	9674	17425	25121	32325	38080	43324	48248	53120	57936	62472
	12.9	19.9	22.3	25.6	28.6	29.1	28.2	26.5	25.0	23.6	21.2
		89.1	70.3	63.7	58.0	48.9	41.2	34.7	29.8	25.8	22.1
0.6	19.1	16.3	14.5	12.7	10.9	9.3	7.9	6.5	5.3	4.1	3.0
	0	10330	18069	25730	33196	39070	44525	49705	54518	59055	63209
	12.9	24.5	27.2	30.1	34.3	35.9	36.4	36.4	34.4	31.1	26.0
		102.0	76.6	67.7	62.2	52.8	45.1	38.8	33.2	28.3	23.6
0.55	19.1	16.2	14.3	12.5	10.7	9.0	7.6	6.2	4.9	3.8	2.9
	0	10715	18549	26260	33759	40075	45698	50996	55820	60054	63759
	12.9	27.6	32.2	35.1	39.1	44.4	46.2	47.0	45.1	39.0	30.5
		109.5	81.3	71.1	65.0	56.7	48.9	42.4	36.4	30.5	24.6
0.5	19.1	16.1	14.2	12.4	10.6	8.8	7.2	5.9	4.7	3.6	2.7
	0	11020	18916	26656	34339	41039	46857	52021	56759	60753	64344
	12.9	30.7	37.4	40.6	45.1	54.2	58.1	57.3	54.1	46.1	36.5
		115.4	84.9	73.7	67.8	60.5	52.7	45.3	38.7	32.0	25.8

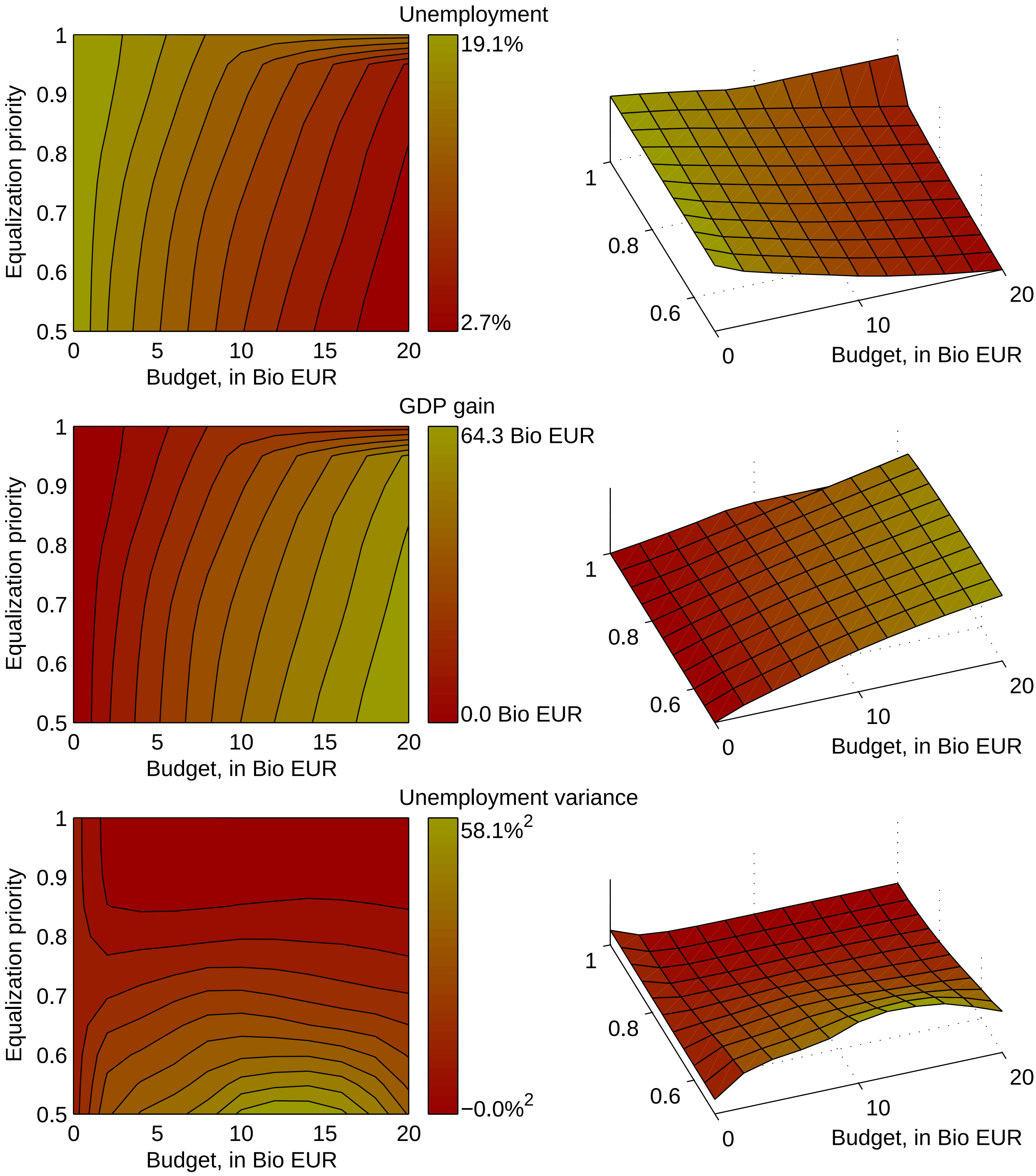

Figure 6: Three target variables optimized under variable budget for East Germany 2004

the three target indices optimized for target weight ratio $(1-c) : 0 : c$ and given budget. The two- and three-dimensional plots of the 'relief' produced by the three target variables are shown in Figure 6.

The fourth element of the cell is the 'Profitability' of the investment in the regional policy which characterizes the tax returns from additional jobs. For instance, suppose that the GDP increment due to the jobs subsidized for 1 Mio EUR aid is 3 Mio EUR. The taxes from these additional 3 Mio EUR bring the state 39.1% tax (OECD estimation of the tax ratio in Germany for 2002), or 1.173 Mio EUR. Then the

$$\text{'Profit' of the state} = 1.173 - 1 = 0.173 \text{ Mio EUR}, \quad \text{or} \quad 17.3\% \ .$$

The relief of the GDP exhibits decreasing marginal returns from the budget increment. It means that governmental investments in the regional policy are not profitable beyond certain limits. Besides, because of linearity of the prediction model, its forecast is getting less reliable as the distance from the initial point increases. This means that the model results for extreme target weight ratios and budgets should be interpreted with reservations.

Finally, mention that the cases of West Germany or of the whole of Germany are analogous, and we do not discuss them here.

5 Conclusions

1. **Non-optimal implementation misinterpreted as uselessness of active labour market policies**

   Comparing with the optimal budget distribution, the efficiency of the actual budget distribution in 2000–2002 is about 4% (Section "Analysis of the past practice"). Such a bad implementation of active labour market policies can be responsible for their low efficiency reported in some empirical studies misinterpreted as their uselessness.

2. **Closeness of targets *Maximization of Employment and of GDP***

   The model reveals a high operational correlation between two policy targets, maximization of employment and maximization of GDP (Paragraph "Triangle of priorities"). It means that subsidizing jobs in productive branches best contributes to the competitiveness of the national economy and most efficiently reduces unemployment. From the operational viewpoint these targets fuse into one and the number of effective targets is reduced from three to two.

3. **Importance of the target *Equalization of Regional Unemployment Rates***

   Disregarding the equalization criterion causes structural disproportions with a number of negative consequences (Paragraph "One-target and three-target optimization"). From the operational viewpoint, it results in large deviations from the starting planning point, making the model inaccurate and unreliable. Therefore, equalization is also needed to keep the situation under operational control (Paragraph "Notes on the model assumptions").

4. **Consequence of overemphasizing the target *Equalization***

   On the other hand, overemphasizing the equalization reduces the competitiveness of the national economy (Paragraph "Triangle of priorities"). For instance, attempts to quickly equalize East and West Germany by subsidizing one at the price of not subsidizing the other turned out to have higher social costs than expected. The equilibrium in West Germany was violated, which reduced the competitiveness of West German industry and caused high unemployment (as follows from Paragraph "Triangle of priorities"). On the other hand, the released funds transferred to East Germany turned out to be insufficient, resulting in no East–West compensation. Regarded from the viewpoint of economic competitiveness, West and East Germany should be considered jointly and adjusting budgeting proportions can be another issue for optimization.

5. **Managerial aspects of active labour market policies**

   Regional policy can be regarded as a profitable governmental enterprize. The model discussed enables policy makers to estimate tax returns from the jobs subsidized and thereby to take into account profits from investments in active labour market policies (Paragraph "Flexibilizing the budget").

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