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Tangian, Andranik S.

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Andranik S. Tangian

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Privatdozent Dr. Dr. Andranik Tangian
WSI in der Hans Böckler Stiftung
Hans-Böckler-Straße 39
D-40476 Düsseldorf
Tel: +49 211 7778-259
Fax: +49 211 7778-190
Andranik-Tangian@Boeckler.De

Abstract

Reducing disparities among regions within European countries together with economic development is the aim of European and national structural policies. In particular, a European grant contributes to the German governmental program for reducing and equalizing regional unemployment. The goal is to bring unemployment down to the national average by creating new and/or by safeguarding existing jobs, which also contributes to decreasing national unemployment and to GDP growth.

The distribution of available aid among 271 German labor market regions is considered as an econometric decision problem with three targets: (1) minimization of unemployment, (2) maximization of GDP, and (3) equalization of regional unemployment rates, subject to the budget constraint and some administrative restrictions. To prepare grounds for optimization, econometric predictions are made for the year 2004 from regional data 1994–2001.

Compared with the previous Discussion Paper 115, the given work contains four new items:

- The German regional policy is optimized not only with regard to equalizing the regional unemployment, but also with regard to reducing national unemployment and GDP growth.

- The source data are extended from a single period of observations 2000-2001 to yearly data 1994–2001.

- The analysis of past developments is no longer the goal of the model but a means to make decisions for the future.

- The number of control parameters is reduced to a necessary minimum implemented in a user interface in form of tables and figures visualizing the topology of optimal planning.

The model can be regarded as a prototype of decision-aid for designing regional policy at national and European levels.

Keywords: European Commission, structural fund grants, regional policy, unemployment, equalizing regional unemployment rates, economic growth, optimal planning.

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

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Contents

Chapter 1

Introduction

1.1 Regional policy

Increasing employment, stimulating economic growth, and reducing disparities among regions are the objectives of both German and European regional policies. In recent years multi-billion national and European grants were given to create new and/or to safeguard existing jobs. First of all it concerns permanent jobs which are most important in providing welfare and social stability.

In particular, a European grant contributes to the German governmental program for equalizing regional unemployment by creating new and/or by safeguarding existing jobs (Deutscher Bundestag 2002, Tetsch et al. 1996), which also contributes to reducing the general unemployment and to GDP growth.

The 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 prevents from structural disproportions. A limited grant naturally results in a trend to subsidize first the jobs which need less subsidies rather than the jobs which are 'expensive' for grant-givers. Since the amount of aid pro job depends of prevailing regional industries and services, certain regions are little supported, while others get too much aid. This decreases the average unemployment but increases the disparity among regions.

The regional unemployment rate is one of most important indicators of socio-economical equilibrium. Besides, it characterizes the regional governmental performance and serves as a governmental assistance criterion. Its equalization all over the country is expected to improve national output and 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 troubles 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.

Compared with the unemployment at national and intra-national levels, the 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 just 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 (some are not implemented in formulas) 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.

1.2 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 rersults.

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.

1.3 Regional policy and optimization

The point left with little attention is the quality of realizing governmental programs. 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." It can imply that not the policies intended but their implementation is responsible for their low efficiency reported in empirical studies. 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 causes migrations which reduce local effects.

Lechner and his colleagues (2003) took part in developing a statistical expert system which customizes the offer for each particular unemployed client. This may be the only instance of any kind of optimization approach in the vast research on active labor market policies. (In a personal communication Lechner was somewhat surprised to learn about my optimization interpretation of his work. Elhorst after having compiled a comprehensive survey was not aware of any optimization approach.)

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). As far as it concerns market relations, the (quasi) optimization is guided by 'the invisible hand', Adam Smith's (1776) metaphor for competition. This, however, is not the case in the public sector with central planning and budget governmental programs. Consequently, optimization should be primarily applied 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 optimization. Among other things, both Tinbergen and Frisch were faced to 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 exist 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 allowed 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.

1.4 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).[1] Tinbergen's approach was further developed by Theil (1964), Fox et al. (1966), Chow (1975) and other leading economists.

Tinbergen's view at econometric decision models was 'more objectivistic' than that

[1]Strictly 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, absolute figures, dollar, or EURO. Determining their substitution rates brings the problem back to Frisch's interviews.

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 Dantzing 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 and Strøm (2002), "Frisch left this field of interest with work undone".

Gruber (2002) remembers that in 1965, after 35 years of existence of the Econometric Society and 16 years after the idea of econometric decision models had been introduced, he found no operational method for constructing objective functions. In both American and German dissertations Gruber (1965, 1967) had to use a heuristic quadratic objective function with no cross-products and roughly estimated coefficients of squared variables.

In subsequent years the situation did not improve much (Gruber 1979) and he tried to animate studies in econometric decision models by having organized four international conferences (Gruber 1983, 1991; Tangian and Gruber 1997, 2002). Interesting experiments were reported by Merkies; for the self-survey see Merkies (2002). A special method for constructing quadratic and additive objective functions was developed by Tangian (2001–2003a) and applied by Hilles and Tangian (2002), Schwarm (2002), and Teibach (2002).

Dealing with econometric decision models turned out to be more complex than initially expected. Compared with purely econometric models, they include an additional element, the objective function, and result in optimization problems to be solved. Unlike statistical methods applicable to almost all data sets, optimization techniques are not that universal. Respectively, econometric models are generally solvable but econometric decision models are not.

This makes building a decision model a kind of art. It assumes the knowledge of the subject domain. Selecting important factors, sorting out secondary ones, and formalizing ill-defined notions, relations, and preferences by variables, equalities, inequalities, and objective functions requires intuition and inventiveness. Configuring sophisticated optimization methods into a consistent model needs mathematical skills. Finally, the whole construct must be mathematically manageable and computable.

These claims explain why purely econometric models prevail over their optimization extensions. Another cause is the situation in mathematics and computer science. Statistics as a mathematical discipline was well developed before the invention of computers, and statistical packages became available already in the 1960–1970s. Optimization, or *mathematical programming*, was developed mainly after the Second World War just to meet new technical endeavors. Accordingly, optimization software was delayed, especially in the user-friendliness, by at least 20 years.

The last but not least cause of disregarding decision models in economics is the specificity of scholarly work itself. Statistics meets its habitual tasks of description, classification, analysis, and systematization. Decision making belongs to the competence of engineers, managers, and policy makers. So a psychological factor is also present.

Summing up what has been said, econometric decision models are still in their infancy. Due to a delay in their development and other difficulties, they are much less used by scholars than purely econometric models. The latter are often sufficient as explaining the dependence of economic variables and thereby restricting the choice of economic policies to feasible ones. However, the policies restricted that way are still too numerous to make the final selection. For this purpose an operational objective function, which distinguishes a decision model, is required.

In particularly it is the case of active labor market policies. Econometric studies analyze their effects: short- and long-term employment, labor demand, migration, future prospects of participants, etc. It is recognized that labor market policies are implemented administratively with little use of optimization methods. Therefore, there is a hope that developing dedicated decision models can optimize them and improve their performance.

1.5 About the given work

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 1994–2001 all eligible regions received yearly about 2.0–2.8 billion EUR; West Germany received about 250–280 Mio, about 1/9, and East Germany — 2.0–2.5.1 Mio, 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 the employment and GDP as well as to equalize regional unemployment, according to the goals of European and national structural policies. The model operates on some source data transformed to a certain form and consists of three blocks: econometric prediction, optimization, and analysis. The modelling falls into the following steps.

- **Collecting regional data**

  These data are available from Bundesamt für Wirtschaft und Ausfuhrkontrolle (2003), Bundesanstalt für Arbeit (2003a), and Statistisches Bundesamt (2003).

- **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 1.2. 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.

- **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.

- **Building a decision model**

  It remains to impose the total budget constraint and to restrict the aid to the eligible regions. The objective function considered is a weighted sum of the target variables, with the target weights reflecting their importance. The problem operationalized that way is linear-quadratic, with a quadratic objective function minimized subject to a linear budget constraint and eligibility restrictions.

- **Solving the optimization problem**

  The linearly restricted quadratic programming problem is implemented in a computer program written in the MATLAB programming environment.

- **User interface to analyze optimal solutions**

  The optimization is performed for West Germany and East Germany with separate budgets, as well as for whole Germany with a joint budget. Some tabular and graphical representations are suggested to facilitate the work with the model (= user interface), in particular, to trace the practical effect of assigning target weights.

Chapter 2, "Model", contains rigorous assumptions and mathematical propositions. The 'motor' of the model is the *variance operator* which reduces computing the variance to a vector/matrix multiplication, separates linear and quadratic operations, and thereby makes the optimization problem solvable.

Chapter 3, "Results", explains the model output represented by figures and tables. Then we comment on the optimal aid distribution among the eligible regions.

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

Chapter 2

Model

2.1 Empirical data 1994–2001

For our model, we transform the source data 1994–2001 on 271 German labour market regions. For each region, we define four *independent variables*, meaning that no variable can be expressed in others. The independence is important to avoid contradictions in forecasts-2004. For definitions and sample see Table 2.1. Blank spaces mean that the region received no aid this year.

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

The number of net employed and of net unemployed are the employment trends free from external interventions in the form of creating new or safeguarding existing jobs.

The aid pro job is in fact the cost of one job for grant givers. Subsidizing the regions where this cost is low implies a high employment 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 to emerge in low productive branches. Our investigation disproves this statement.

2.2 Econometric forecast for 2004

For each region, the four regional variables are regarded as functions of time. They are predicted for 2004 by the common linear regression techniques. More specifically, the regional variables are expressed in the independent variable "Year" which indirectly incorporates numerous influential factors. The linearity assumption means the first-order approximation of the unknown 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.

The forecast is made whenever the data on the region are available, also for the regions which received the aid irregularly. East German regions received the aid every year, the related data are most complete, and the related forecast is therefore most reliable.

The prediction results for all 271 regions are collected in the first section of Table 3.1, which displays the model output. It contains some unrealistic predictions for 2004 like negative or extremely high expenditures pro subsidized job. This is explained by large

Table 2.1: Source data and independent regional variables 1994–2001

Regional variable	Regional source data	Units
	GDP	Mio EUR
	Number of employed	Ths
	Number of unemployed	Ths
	Aid granted (to the region)	Mio EUR
	Number of permanent jobs subsidized (created and safeguarded)	Ths
Productivity	$= \frac{\text{GDP}}{\text{Number of employed}}$	Ths EUR/employee
Net employed	= Number of employed − Number of permanent jobs subsidized	Ths
Net unemployed	= Number of unemployed + Number of permanent jobs subsidized	Ths
Aid pro job	$= \frac{\text{Aid granted}}{\text{Number of permanent jobs subsidized}}$	Ths EUR/job

Sample source data 1994 and their transformation into regional variables

Nr.	Region	Data: Employed	Data: Unemployed	Data: GDP	Data: Amount of aid	Data: Subsidized permanent jobs	Variables (data derivatives): Net employed (no aid)	Variables: Net unemployed (no aid)	Variables: Productivity GDP/ Empl.	Variables: Aid pro job
		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	
...										

random leaps of yearly indices which cause rather steep regression lines. Since the target year 2004 is distant from the period of observations 1994–2001 these lines have an additional room to go out of reasonable limits.

These unrealistic predictions are corrected by the technique of **constrained forecast**. It replaces the prediction outlier by the corresponding maximal or minimal observation during the control period. The constrained forecast is given in the second section of Table 3.1. The forecast for Productivity is not constrained, because the development of the regional productivity is not that random and is quasi-linear in all the regions.

The section "Constrained forecast" in Table 3.1 contains additionally the vector $\boldsymbol{n}$ of predicted regional net unemployment rates. It is directly derived from the regional figures

Table 2.2: Estimates derived from the constrained forecast 2004

Vector	Name	Expressions in predicted figures	Units
$\boldsymbol{u}$	Net unemployed	= Net unemployed	Ths
$\boldsymbol{n}$	Net unemployment rate 2004	$= \frac{\text{Net unemployed}}{\text{Net employed} + \text{Net unemployed}} \cdot 100$	%
		Estimated efficiency of 1 Mio EUR Aid in 2004	
$\boldsymbol{j}$	Additional jobs	$= \frac{1}{\text{Aid pro job}}$	Ths
$\boldsymbol{g}$	Gain in GDP	= Productivity · Additional jobs	
		$= \frac{\text{Productivity}}{\text{Aid pro job}}$	Mio EUR
$\boldsymbol{d}$	Decrement in unemployment rate	$= \frac{\text{Additional jobs}}{\text{Net employed} + \text{Net unemployed}} \cdot 100\%$	
		$= \frac{100}{\text{Aid pro job} \cdot (\text{Net employed} + \text{Net unemployed})}$	%

for net employment and unemployment. Generally, the forecast vectors with regional figures used further by the model are denoted by boldface letters. It is also the case of the vector $\boldsymbol{u}$ with the number of unemployed predicted in the regions.

The constraint forecast for 2004 allows to estimate the effect of aid to each region. The effect reduced to the reference aid of one Mio EUR is considered in three domains (for rigorous definitions see Table 2.2):

- **Additional jobs**, that is, we estimate how many additional jobs in the region can be subsidized in 2004 with one Mio EUR. These estimates are collected into the 271-vector $\boldsymbol{j}$ (= jobs) which will be considered while minimizing the national unemployment. Since the regional variables 'Aid pro job' are in Ths EUR, and the reference aid is one Mio EUR, the estimates 'Additional jobs' are automatically converted into Ths.

- **GDP gain**, that is, we estimate the gain in GDP due to the additional jobs under the expected regional productivity. These estimates are collected into the 271-vector $\boldsymbol{g}$ (= GDP) which will be considered while maximizing GDP. Since the regional variables 'Additional jobs' are in Ths, and 'Productivity' are in Ths EUR pro employee, the estimates 'GDP gain' are automatically converted into Mio EUR.

- **Decrement in unemployment rate**, that is, we estimate the decrement in the regional unemployment rates due to the additional jobs. These estimates are collected into the 271-vector $\boldsymbol{d}$ (= decrement), which will be considered while equalizing the regional unemployment. Since all the incoming figures for estimating 'Decrement in unemployment rate' are given in Ths, only the multiplication by 100% is required.

2.3 Target variables

Define three target variables (= partial criteria): the national increase in employment, the GDP gain, and the measure of disparity among regional unemployment rates. For this purpose introduce the following notation.

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

$\boldsymbol{j}'\boldsymbol{x}$ the total additional number of jobs in 2004 due to the aid $\boldsymbol{x}$; here $'$ denotes the operation of vector/matrix transpose, and $\boldsymbol{j}'\boldsymbol{x}$ is the scalar product of two vectors,

$\boldsymbol{g}'\boldsymbol{x}$ the additional GDP, in Mio EUR, due to the aid $\boldsymbol{x}$,

$\boldsymbol{n} - \boldsymbol{D}\boldsymbol{x}$ the vector of regional ('gross') unemployment rates, in %, which results from the decrement $\boldsymbol{D}\boldsymbol{x}$ due to aid $\boldsymbol{x}$ in the net unemployment $\boldsymbol{n}$; here $\boldsymbol{D} = \mathrm{diag}\boldsymbol{d}$ is the diagonal matrix with the elements of vector $\boldsymbol{d}$ on its main diagonal.

Define the measure of *regional unemployment disparity* to be the variance of regional unemployment rates.

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

$$\frac{1}{m-1}\sum_{r=1}^{m}\left(y_r - \frac{1}{m}\sum_{s=1}^{m} y_s\right)^2 = \frac{1}{m-1}\|\boldsymbol{V}\boldsymbol{y}\|^2 \quad , \tag{2.1}$$

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,

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

Theorem 2 (Unemployment disparity among regions)
The variance of the 'gross' unemployment rates of m regions after they have received aid $\boldsymbol{x}$ is as follows

$$\frac{1}{m-1}\|\boldsymbol{V}(\boldsymbol{n} - \boldsymbol{D}\boldsymbol{x})\|^2 = \frac{1}{m-1}\Big(\boldsymbol{x}'\boldsymbol{D}\boldsymbol{V}\boldsymbol{D}\boldsymbol{x} - 2\boldsymbol{n}'\boldsymbol{V}\boldsymbol{D}\boldsymbol{x} + \boldsymbol{n}'\boldsymbol{V}\boldsymbol{n}\Big) \; .$$

Proof. Substitute $\boldsymbol{y} = \boldsymbol{n} - \boldsymbol{D}\boldsymbol{x}$ into (2.1) and derive:

$$\begin{aligned} \frac{1}{m-1}\|\boldsymbol{V}(\boldsymbol{n} - \boldsymbol{D}\boldsymbol{x})\|^2 &= \frac{1}{m-1}(\boldsymbol{V}\boldsymbol{n} - \boldsymbol{V}\boldsymbol{D}\boldsymbol{x})'(\boldsymbol{V}\boldsymbol{n} - \boldsymbol{V}\boldsymbol{D}\boldsymbol{x}) \quad \overset{(AB)'=B'A',\ \boldsymbol{V}'=\boldsymbol{V}}{\Longrightarrow} \\ &= \frac{1}{m-1}(\boldsymbol{n}'\boldsymbol{V} - \boldsymbol{x}'\boldsymbol{D}\boldsymbol{V})(\boldsymbol{V}\boldsymbol{n} - \boldsymbol{V}\boldsymbol{D}\boldsymbol{x}) \quad \overset{\boldsymbol{V}\boldsymbol{V}=\boldsymbol{V}}{\Longrightarrow} \\ &= \frac{1}{m-1}\Big(\boldsymbol{n}'\boldsymbol{V}\boldsymbol{n} - \boldsymbol{x}'\boldsymbol{D}\boldsymbol{V}\boldsymbol{n} - \boldsymbol{n}'\boldsymbol{V}\boldsymbol{D}\boldsymbol{x} + \boldsymbol{x}'\boldsymbol{D}\boldsymbol{V}\boldsymbol{D}\boldsymbol{x}\Big) \quad \overset{(AB)'=B'A'}{\Longrightarrow} \\ &= \frac{1}{m-1}\Big(\boldsymbol{x}'\boldsymbol{D}\boldsymbol{V}\boldsymbol{D}\boldsymbol{x} - 2\boldsymbol{n}'\boldsymbol{V}\boldsymbol{D}\boldsymbol{x} + \boldsymbol{n}'\boldsymbol{V}\boldsymbol{n}\Big) \; . \end{aligned}$$

Thus the three target variables are linear or quadratic functions in aid $\boldsymbol{x}$ with the coefficients estimated econometrically from empirical data, see Table 2.3.

Table 2.3: Target variables

Notation	Name	Expression	Units
$t_1(\boldsymbol{x})$	Additional jobs	$\boldsymbol{j}'\boldsymbol{x}$	Ths
$t_2(\boldsymbol{x})$	GDP gain	$\boldsymbol{g}'\boldsymbol{x}$	Mio EUR
$t_3(\boldsymbol{x})$	Regional unemployment disparity	$\frac{1}{m-1}\Big(\boldsymbol{x}'\boldsymbol{DVDx} - 2\boldsymbol{n}'\boldsymbol{VDx} + \boldsymbol{n}'\boldsymbol{Vn}\Big)$	$\%^2$

2.4 Optimal regional policy

On the one hand, we wish to increase the employment and GDP. On the other hand, we wish to reduce the disparity among regional unemployment rates. These intentions are implemented in the following proposition.

Theorem 3 (Optimization of regional policy)
Given total budget B, list of the regions eligible to receive the aid, 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

$$\begin{aligned} \text{maximize} \quad & at_1(\boldsymbol{x}) + bt_2(\boldsymbol{x}) - ct_3(\boldsymbol{x}) \\ \text{subject to} \quad & \sum_r x_r \leq B \quad \text{(budget constraint)} \\ & \boldsymbol{0} \leq \boldsymbol{Jx} \leq \boldsymbol{u} \quad \text{(fewer jobs than unemployed in the region)} \\ & x_r = 0 \quad \text{for non-eligible regions } r \ , \end{aligned} \tag{2.2}$$

where $\boldsymbol{J} = \operatorname{diag}\boldsymbol{j}$ is the diagonal matrix with elements of vector $\boldsymbol{j}$ on its main diagonal. Taking into account the expressions from Table 2.3, we obtain a quadratic programming problem with the objective function

$$at_1(\boldsymbol{x}) + bt_2(\boldsymbol{x}) - ct_3(\boldsymbol{x}) = -\boldsymbol{x}'\left(\frac{c}{m-1}\boldsymbol{DVD}\right)\boldsymbol{x} + \Big(2c\boldsymbol{n}'\boldsymbol{VD} + a\boldsymbol{j} + b\boldsymbol{g}\Big)'\boldsymbol{x}$$

to be maximized subject to linear equality and inequality constraints (the constant $-c\boldsymbol{n}'\boldsymbol{Vn}$ plays no role in the maximization and is omitted). Its Hessian $\boldsymbol{DVD}$ is symmetric implying the problem solvability.

Putting all the weights a, b, c but one equal to 0, we reduce the problem (2.2) to three one-target problems. Their solutions are given in the last two sections of Table 3.1.

2.5 Normalizing targets and their weights

The values of the target weights a, b, c other than 1 and 0 are misleading because of different ranges of the targets:

t_1, 'Additional jobs', varies from 50 to 500 Ths,

t_2, 'GDP gain', varies from 6 to 17 Bio EUR, and

t_3, 'Variance of regional unemployment', varies from 3 to $40\%^2$.

Contrary to intuition, 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. In order to take target t_3 into consideration, its weight c must be disproportionately large, and the weight b of t_2 very small, at the limit of computer discrimination. To avoid such situations, we normalize the target variables t by reducing their ranges to the segment $[0; 1]$, and restore them if necessary:

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

The extreme values of the target variables are obtained from solving three one-target problems as has been described in the previous section, see Table 3.2.

Normalizing target variables does not affect the optimization, but just rearranges the space of decision parameters. In fact we only insert some factors between target variables and their weights a, b, c which restore the intuitive meaning of the latter. On the other hand, we gain in the computational accuracy.

From now on we refer to normalized weights of target variables. In particular, the target weight ratio $2 : 1 : 7$ in the fourth optimization problem on East Germany is specified for normalized target variables.

Chapter 3

Results

3.1 One-target optimization

Table 3.1 contains solutions to 12 optimization problems. The effect of optimal aid distribution on unemployment, GDP, and regional unemployment equalization are presented in Table 3.2 and Figures 3.1–3.2. The sections of Table 3.2 in a small font are optional and are derived for completeness from the main solutions shown by the full-sized font.

Four problems concern West Germany with a separate budget. The solutions are given in the next to last section of Table 3.1, rows 1–204. The effect on the regional unemployment is shown by blue bars in four plots of Figure 3.1. (All further figures related to West Germany are also in blue.) The optimization summary is put in the upper-left section of Table 3.2.

Four problems concern East Germany, also with a separate budget. The solutions are given in the remaining rows 205–271. They are illustrated with red bars in four plots of Figure 3.1. (All further figures related to East Germany are also in red.) The optimization summary is given in the middle-left section of Table 3.2.

Finally, four problems concern Germany as a whole with a joint budget. The solutions occupy the whole last section of Table 3.1. They are illustrated with whole plots in Figure 3.1, all in green, as well as further figures related to whole Germany. The optimization summary is given in the bottom-right section of Table 3.2.

For instance, consider East Germany. Its separate budget $B = 1653.38$ Mio EUR for 2004 is indicated at the foot of Tables 3.1 and 3.2. The budget is predicted from years 1994–2001, when it gradually decreased. All the $m = 67$ East German regions were eligible to receive the aid, which we accept for the year 2004 in (2.2). In case of West Germany the list of eligible regions varied from year to year, and we accept the most recent one dated 2001.

The predicted net regional unemployment rates (with no aid) are shown in Figure 3.1 by the stair contour, the same in all four plots. 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.

- The first model with the target weight ratio $a : b : c = 1 : 0 : 0$ actually reduces the consideration to the first target, **Maximal employment**. Respectively, the model selects 15 of 67 regions with most 'cheap' jobs (among others, Wiemar, Eisenach,

Table 3.1: 2004-forecast for 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				Joint budget of East and West			
							$\boldsymbol{u}$	$\boldsymbol{n}$		$\boldsymbol{j}$	$\boldsymbol{g}$	$\boldsymbol{d}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$
		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	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	Mio.EUR	Mio.EUR	Mio.EUR	Mio.EUR
1	Husum	78.03	7.44	51.5	8.54	77.22	6.84	8.14	8.54	0.117	6.0	0.14								
2	Heide	57.79	7.14	54.8	−40.08	57.30	6.37	10.00	1.76	0.567	31.1	0.89								
3	Itzehoe	57.19	6.67	70.8	6.18	56.30	5.95	9.56	6.15	0.162	11.5	0.26								
4	Flensburg	131.75	13.99	47.8	−19.32	131.46	13.99	9.62	2.57	0.389	18.6	0.27	35.97	35.97	3.60	9.22	35.97	35.97		14.14
5	Lübeck	197.01	25.75	52.2	3.19	197.01	22.76	10.35	3.19	0.314	16.4	0.14	22.23	34.83	4.41	16.89	72.52	72.52		37.81
6	Kiel	342.91	35.67	54.6	12.15	342.91	35.67	9.42	12.15	0.082	4.5	0.02								
7	Ratzeburg	62.86	7.94	53.5	3.47	61.10	7.08	10.38	3.45	0.289	15.5	0.42								
8	Hamburg	1454.86	117.69	69.8	46.85	1444.50	117.69	7.53	46.67	0.021	1.5	0.00								
9	Braunschweig	222.59	27.55	53.8	−5.04	222.59	27.55	11.01	3.50	0.286	15.4	0.11			6.24	21.39	96.42	96.42		52.66
10	Salzgitter	59.56	6.93	60.7	6.60	59.36	6.93	10.45	6.01	0.166	10.1	0.25			6.83	6.06	41.62	41.62		1.34
11	Wolfsburg	153.69	12.16	82.7	−47.63	149.70	12.76	7.85	7.32	0.137	11.3	0.08								
12	Göttingen	124.44	17.66	49.0	2.75	124.44	17.34	12.23	2.75	0.364	17.8	0.26	47.61	47.61	13.72	19.08	47.61	47.61		23.69
13	Goslar	63.92	10.49	53.6	8.39	65.90	9.91	13.07	8.39	0.119	6.4	0.16			22.63	15.51				4.79
14	Helmstedt	28.45	6.11	68.2	−18.46	28.45	6.11	17.69	1.56	0.641	43.7	1.85	9.54	9.54	5.43	5.79	9.54	9.54	3.98	5.13
15	Einbeck	58.73	10.46	47.7	−1.52	58.73	10.46	15.12	2.65	0.377	18.0	0.54	27.76	27.76	13.01	14.32	27.76	27.76	7.43	13.17
16	Osterode	34.69	7.02	53.8	17.35	35.36	7.02	16.57	17.35	0.058	3.1	0.14			49.50	32.44			16.38	9.41
17	Hannover	606.14	55.84	56.1		605.40	55.84	8.44												
18	Sulingen	87.19	7.50	48.8	−3.05	83.20	7.50	8.27	2.33	0.429	20.9	0.47								
19	Hameln	68.28	10.40	53.9	29.94	68.28	10.24	13.04	29.94	0.033	1.8	0.04								
20	Hildesheim	122.01	14.08	48.9	18.93	122.01	14.08	10.35	12.83	0.078	3.8	0.06								
21	Holzminden	31.18	3.99	49.9	14.88	31.72	3.99	11.18	14.88	0.067	3.4	0.19			10.66	2.31				
22	Nienburg	49.07	4.94	60.6	13.97	49.07	4.94	9.14	13.97	0.072	4.3	0.13								
23	Stadthagen	61.20	6.75	49.7	12.01	60.20	6.75	10.08	3.28	0.305	15.2	0.46								
24	Celle	70.17	11.10	55.5	7.74	70.17	9.95	12.42	7.74	0.129	7.2	0.16			18.31	12.54		76.97		3.51
25	Lüneburg	70.70	9.80	47.1	1.58	68.71	8.94	11.51	3.62	0.277	13.0	0.36			8.87	10.13	32.32	32.32		8.31
26	Zeven	68.11	6.02	49.5	65.68	67.20	6.02	8.22	28.67	0.035	1.7	0.05								
27	Soltau	63.21	6.20	48.7	14.38	63.21	5.71	8.29	14.38	0.070	3.4	0.10								
28	Stade	75.54	7.05	61.6	10.05	73.60	7.05	8.75	10.00	0.100	6.2	0.12								
29	Uelzen	58.02	9.66	49.2	4.64	58.02	8.74	13.09	4.64	0.216	10.6	0.32			14.40	14.72	40.55	40.55	3.94	11.42
30	Verden	57.15	4.41	55.3	2.74	56.10	4.41	7.29	2.73	0.367	20.3	0.61								
31	Emden	106.69	13.72	50.5	29.34	103.40	13.67	11.68	29.34	0.034	1.7	0.03								
32	Westerstede	48.72	5.54	47.0	33.64	47.16	5.39	10.25	32.50	0.031	1.4	0.06								
33	Oldenburg	145.06	14.42	50.5	−0.62	139.58	14.20	9.23	2.94	0.341	17.2	0.22	41.68	41.68	1.46	7.76	41.68	41.68		14.28
34	Osnabrück	258.14	17.37	51.9		250.70	17.50	6.53												

Table 3.1: 2004-forecast for 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				Joint budget of East and West			
							$\boldsymbol{u}$	$\boldsymbol{n}$		$\boldsymbol{j}$	$\boldsymbol{g}$	$\boldsymbol{d}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$
		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	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	Mio.EUR	Mio.EUR	Mio.EUR	Mio.EUR
35	Wilhelmshaven	104.49	13.57	49.9	10.50	104.49	13.57	11.49	10.50	0.095	4.8	0.08								
36	Cloppenburg	65.61	6.36	49.8	12.02	62.00	6.36	9.30	12.02	0.083	4.1	0.12								
37	Lingen	140.00	12.32	60.1	20.97	134.90	12.32	8.37	20.97	0.048	2.9	0.03								
38	Nordhorn	57.29	4.43	47.3	25.98	55.07	4.43	7.45	25.98	0.038	1.8	0.06								
39	Leer	58.37	8.96	51.6	22.88	56.61	8.96	13.66	22.88	0.044	2.3	0.07			19.73					
40	Vechta	69.67	3.81	51.4	−13.37	65.30	3.81	5.51	15.32	0.065	3.4	0.09								
41	Nordenham	34.81	4.25	67.1	23.11	34.81	4.25	10.89	23.11	0.043	2.9	0.11			4.47					
42	Bremen	387.92	43.47	60.7	10.85	387.92	43.47	10.08	10.85	0.092	5.6	0.02								
43	Bremerhaven	123.89	20.56	49.7	14.60	124.10	20.06	13.91	14.60	0.068	3.4	0.05								
44	Hëxter	63.05	6.15	46.4	3.37	62.90	6.15	8.91	3.81	0.262	12.2	0.38								
45	Düsseldorf	884.06	58.46	75.0		863.90	58.46	6.34												
46	Duisburg	495.21	63.33	51.7	11.43	484.73	63.33	11.56	11.43	0.087	4.5	0.02								
47	Essen	390.46	37.81	60.1	−24.95	384.70	37.81	8.95	6.87	0.146	8.7	0.03								
48	Krefeld	121.00	12.16	59.5	42.33	120.50	12.16	9.17	26.60	0.038	2.2	0.03								
49	Viersen	124.93	11.48	54.2		119.50	11.48	8.76												
50	Mönchengladbach	124.87	14.25	53.4	1.36	122.79	14.25	10.40	1.36	0.738	39.4	0.54	19.31	19.31	4.38	8.62	19.31	19.31		11.92
51	Heinsberg	86.86	11.13	47.4	3.81	84.16	11.13	11.68	3.81	0.262	12.4	0.28			11.10	12.77	42.42	42.42		11.61
52	Wuppertal	247.30	23.47	56.5		247.20	23.47	8.67												
53	Schwelm	142.68	14.55	51.7	6.80	141.20	14.55	9.34	6.80	0.147	7.6	0.09								
54	Remscheid	60.45	5.07	52.3		61.10	5.07	7.66												
55	Kleve	126.80	11.85	50.5	63.12	120.30	11.85	8.97	25.76	0.039	2.0	0.03								
56	Aachen	279.99	26.03	53.3	8.58	267.60	26.03	8.86	8.54	0.117	6.2	0.04								
57	Köln	929.21	79.07	63.9		896.20	79.07	8.11												
58	Leverkusen	84.91	7.30	74.7		84.90	7.30	7.92												
59	Bonn	430.73	29.58	51.1		412.60	28.76	6.52												
60	Düren	111.76	10.67	54.1	34.52	108.00	10.67	8.99	34.35	0.029	1.6	0.02								
61	Euskirchen	75.18	6.28	49.7		71.80	5.90	7.59												
62	Gummersbach	132.33	11.24	52.7		125.90	11.24	8.20												
63	Gelsenkirchen	453.69	81.31	48.1	7.40	450.28	77.49	14.68	7.40	0.135	6.5	0.03						353.87		
64	Münster	397.85	26.21	51.0	−23.44	381.70	26.21	6.43	3.55	0.282	14.4	0.07								
65	Borken	179.88	11.46	49.5		170.50	11.46	6.30												
66	Steinfurt	190.74	14.07	47.1	−58.92	183.80	14.07	7.11	14.21	0.070	3.3	0.04								
67	Bielefeld	308.53	29.57	53.6		303.40	29.57	8.88												
68	Gütersloh	187.68	13.61	54.8		180.10	12.97	6.72												

Table 3.1: 2004-forecast for 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				Joint budget of East and West			
							u	n		j	g	d	$x_{1:0:0}$	$x_{0:1:0}$	$x_{0:0:1}$	$x_{2:1:7}$	$x_{1:0:0}$	$x_{0:1:0}$	$x_{0:0:1}$	$x_{2:1:7}$
		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	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	Mio.EUR	Mio.EUR	Mio.EUR	Mio.EUR
69	Detmold	154.13	16.27	53.5	20.10	154.10	15.46	9.12	20.00	0.050	2.7	0.03								
70	Minden	158.79	13.05	52.2		156.10	13.05	7.71												
71	Paderborn	148.50	12.36	50.2		139.30	12.36	8.15												
72	Bochum	200.66	20.93	62.0	27.72	195.80	20.93	9.66	24.91	0.040	2.5	0.02								
73	Dortmund	500.22	74.68	53.8	10.35	499.36	74.68	13.01	10.35	0.097	5.2	0.02								
74	Hagen	97.95	10.17	56.0	105.38	98.60	10.17	9.35	32.00	0.031	1.8	0.03								
75	Lüdenscheid	217.14	16.27	53.8		212.80	16.58	7.23												
76	Meschede	137.22	9.86	50.0		134.70	9.86	6.82												
77	Siegen	151.65	9.87	54.1		148.30	9.87	6.24												
78	Olpe	69.05	4.32	53.6		66.30	4.32	6.11												
79	Soest	145.63	13.11	51.8		139.80	11.93	7.87												
80	Korbach	80.32	6.82	52.7	5.77	80.07	6.82	7.85	5.77	0.173	9.1	0.20					39.40	39.40		
81	Kassel	222.80	28.81	56.4	28.03	222.80	28.81	11.45	17.85	0.056	3.2	0.02								
82	Eschwege	44.19	8.41	50.4	6.23	44.58	8.21	15.55	6.23	0.160	8.1	0.30			23.15	22.24	51.14	51.14	11.88	17.05
83	Schwalm-Eder	69.09	9.86	55.4	9.20	69.71	9.31	11.78	12.00	0.083	4.6	0.11			11.79					
84	Hersfeld	60.89	6.18	56.5	14.17	60.89	6.18	9.21	12.37	0.081	4.6	0.12								
85	Marburg	109.82	9.52	58.3	1.77	109.10	9.52	8.03	1.76	0.567	33.0	0.48								
86	Lauterbach	42.74	5.02	49.7	11.14	43.24	5.02	10.39	11.14	0.090	4.5	0.19			6.47					
87	Fulda	110.97	8.79	54.8	−56.81	108.50	8.79	7.50	6.28	0.159	8.7	0.14								
88	Wetzlar	114.03	9.50	60.1		113.60	9.50	7.72												
89	Gießen	126.16	11.03	54.5		124.30	11.03	8.15												
90	Limburg	66.28	5.71	53.8		65.70	5.71	7.99												
91	Wiesbaden	229.22	16.53	68.0		226.60	16.53	6.80												
92	Frankfurt/Main	1275.23	65.18	77.0		1250.20	65.18	4.96												
93	Hanau	159.76	13.82	63.2		159.00	13.82	7.99												
94	Darmstadt	208.03	13.46	60.7		208.03	13.46	6.08												
95	Erbach	36.61	3.32	52.0		36.20	3.32	8.41												
96	Altenkirchen	49.45	4.77	52.2		48.70	4.77	8.92												
97	Montabaur	87.95	6.45	50.0		85.00	6.45	7.06												
98	Neuwied	80.71	7.17	52.7		77.50	6.51	7.75												
99	Ahrweiler	46.02	4.08	47.8	184.17	44.50	3.98	8.21	52.50	0.019	0.9	0.04								
100	Koblenz	229.10	17.29	52.4	87.99	226.60	16.60	6.83	28.81	0.035	1.8	0.01								
101	Bad Kreuznach	62.42	6.77	51.0	44.39	62.42	6.77	9.79	41.67	0.024	1.2	0.03								
102	Idar-Oberstein	38.78	3.97	45.9	73.85	38.73	3.97	9.30	73.85	0.014	0.6	0.03								

Table 3.1: 2004-forecast for 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				Joint budget of East and West			
							$\boldsymbol{u}$	$\boldsymbol{n}$		$\boldsymbol{j}$	$\boldsymbol{g}$	$\boldsymbol{d}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$
		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	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	Mio.EUR	Mio.EUR	Mio.EUR	Mio.EUR
103	Cochem	29.14	2.09	42.0	75.78	29.14	2.09	6.70	75.78	0.013	0.6	0.04								
104	Simmern	48.71	4.22	49.3	26.29	46.30	4.22	8.35	26.29	0.038	1.9	0.08								
105	Trier	110.90	9.06	49.3	−1.52	109.50	8.98	7.58	10.35	0.097	4.8	0.08								
106	Bernkastel-Wittlich	50.29	3.95	46.5	41.27	49.70	3.95	7.37	41.27	0.024	1.1	0.05								
107	Daun	27.90	1.91	45.2	65.87	26.80	1.91	6.64	45.63	0.022	1.0	0.08								
108	Bitburg	36.06	2.81	51.7	40.88	36.00	2.81	7.23	35.81	0.028	1.4	0.07								
109	Kaiserslautern	141.80	16.69	53.5	15.30	139.07	16.69	10.72	15.30	0.065	3.5	0.04								
110	Landau	68.24	4.94	48.8	−117.03	63.80	4.94	7.19	2.50	0.400	19.5	0.58								
111	Mainz	221.81	12.46	59.9		210.60	12.46	5.58												
112	Alzey-Worms	74.88	8.33	55.8	38.11	73.20	8.33	10.22	37.92	0.026	1.5	0.03								
113	Pirmasens	73.12	9.46	50.0	11.50	73.12	9.46	11.46	11.50	0.087	4.3	0.11			8.67					
114	Ludwigshafen	270.73	21.52	62.0		270.73	21.52	7.36												
115	Germersheim	49.63	4.05	60.7		48.20	4.05	7.75												
116	Merzig	41.22	4.06	46.5	−3.51	40.90	4.06	9.04	3.10	0.322	15.0	0.72	12.61		1.60	2.13	12.61	12.61		0.32
117	St. Wendel	34.23	2.78	57.1	−26.92	32.60	2.78	7.85	1.43	0.700	39.9	1.98								
118	Saarbrücken	369.76	36.11	47.6	−4.13	360.03	36.11	9.12	1.68	0.595	28.3	0.15	60.66	60.66		33.98	60.66	60.66		60.66
119	Homburg/Saar	77.45	7.37	54.2	−4.01	77.10	7.37	8.73	3.43	0.291	15.8	0.34								
120	Stuttgart	1326.66	49.59	68.1		1312.90	53.69	3.93												
121	Göppingen	108.56	4.67	56.9		109.60	5.37	4.67												
122	Heilbronn	235.51	11.31	64.6		225.10	11.60	4.90												
123	Schwäbisch Hall	153.21	6.23	55.6		147.50	6.48	4.21												
124	Tauberbischofsheim	70.90	3.13	49.2		70.90	3.16	4.27												
125	Heidenheim	63.73	3.99	60.6		63.73	3.99	5.90												
126	Aalen	146.85	8.96	55.3		144.30	8.96	5.85												
127	Baden-Baden	146.72	6.94	61.0		142.50	6.94	4.64												
128	Karlsruhe	390.78	20.07	62.2		387.10	20.07	4.93												
129	Heidelberg	319.20	19.98	59.9		306.00	19.98	6.13												
130	Mannheim	317.84	24.04	63.4		312.10	24.04	7.15												
131	Mosbach	62.56	3.73	54.3		61.70	3.73	5.69												
132	Pforzheim	145.98	8.32	55.3		145.10	8.59	5.59												
133	Calw	58.22	2.85	51.9		58.22	2.98	4.87												
134	Freudenstadt	59.66	2.53	55.8		58.30	2.53	4.16												
135	Freiburg	310.40	17.22	50.7		300.90	17.22	5.41												
136	Offenburg	218.95	9.16	54.7		213.80	9.40	4.21												

Table 3.1: 2004-forecast for 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				Joint budget of East and West			
							$\boldsymbol{u}$	$\boldsymbol{n}$		$\boldsymbol{j}$	$\boldsymbol{g}$	$\boldsymbol{d}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$
		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	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	Mio.EUR	Mio.EUR	Mio.EUR	Mio.EUR
137	Rottweil	70.91	2.19	56.9		69.90	2.88	3.95												
138	Villingen-Schwenningen	111.76	3.30	53.2		110.20	4.59	4.00												
139	Tuttlingen	68.41	2.50	57.0		66.10	3.05	4.41												
140	Konstanz	127.10	8.69	56.7		125.10	8.69	6.49												
141	Lörrach	98.04	6.56	57.5		97.30	6.56	6.32												
142	Waldshut	69.99	4.83	53.3		69.00	4.83	6.54												
143	Reutlingen/Tübingen	234.73	9.72	53.5		224.60	11.20	4.75												
144	Balingen	86.88	4.52	55.8		88.00	5.20	5.58												
145	Ulm	249.00	12.28	59.3		242.20	12.28	4.82												
146	Biberach	85.84	3.86	59.5		85.20	3.86	4.33												
147	Friedrichshafen	100.14	4.59	61.5		97.20	4.59	4.51												
148	Ravensburg	137.15	5.10	57.4		134.90	5.17	3.69												
149	Sigmaringen	60.00	3.97	48.6		60.30	3.97	6.17												
150	Bad Reichenhall	45.67	3.22	50.9		47.40	2.96	5.87												
151	Traunstein	80.07	4.15	60.5		79.00	4.15	4.99												
152	Burghausen	57.07	3.66	74.4		55.60	3.63	6.13												
153	Mühldorf	47.47	3.10	57.0		46.20	3.10	6.29												
154	Rosenheim	142.27	6.35	53.4		139.80	6.35	4.34												
155	Bad Tölz	92.61	4.47	54.3		91.00	4.47	4.68												
156	Garmisch-Partenkirchen	42.35	2.02	46.5		42.35	2.02	4.56												
157	Weilheim	57.08	2.39	54.7		56.50	2.39	4.06												
158	Landsberg	47.26	1.80	52.8		44.50	1.80	3.88												
159	München	1511.01	51.98	80.2		1484.90	51.98	3.38												
160	Ingolstadt	219.95	10.00	62.9		210.40	10.49	4.75												
161	Kelheim-Mainburg	47.66	2.89	52.1		46.50	2.89	5.85												
162	Landshut	99.62	5.35	55.3		98.10	5.35	5.17												
163	Dingolfing	57.13	1.93	53.5		53.80	1.93	3.47												
164	Eggenfelden/Pfarrkirchen	52.17	3.64	52.2	−18.63	51.20	3.64	6.64	0.51	1.946	101.6	3.55								
165	Passau	115.88	11.15	51.8	4.76	115.88	11.15	8.78	4.76	0.210	10.9	0.17					53.11	53.11		
166	Freyung	33.80	4.01	42.5	4.67	33.80	3.64	9.71	4.67	0.214	9.1	0.57			2.99	3.05	16.97	16.97		0.10
167	Regen-Zwisel	36.41	3.47	44.7	57.46	36.41	3.47	8.71	57.46	0.017	0.8	0.04								
168	Deggendorf	58.29	4.01	53.6	−170.75	57.30	4.01	6.54	1.33	0.750	40.2	1.22								
169	Straubing	64.36	4.63	53.1	4.65	63.50	4.63	6.80	4.65	0.215	11.4	0.32								
170	Cham	61.70	5.64	47.3	7.37	59.98	5.08	7.81	7.37	0.136	6.4	0.21								

Table 3.1: 2004-forecast for 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				Joint budget of East and West			
							$\boldsymbol{u}$	$\boldsymbol{n}$		$\boldsymbol{j}$	$\boldsymbol{g}$	$\boldsymbol{d}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$
		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	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	Mio.EUR	Mio.EUR	Mio.EUR	Mio.EUR
171	Regensburg	186.30	10.75	61.8		180.70	10.75	5.62												
172	Schwandorf	67.08	4.37	51.5	−27.22	65.70	4.37	6.23	2.15	0.465	23.9	0.66								
173	Amberg	68.75	6.07	54.6	−66.72	68.75	6.07	8.11	1.12	0.890	48.6	1.19								
174	Neumarkt	57.02	4.08	53.2		55.00	4.08	6.90												
175	Weiden	70.67	5.18	52.1	−29.57	70.50	5.18	6.84	0.29	3.500	182.4	4.62								
176	Marktredwitz	66.79	9.48	50.1	−10.47	69.69	8.85	11.26	3.24	0.308	15.5	0.39			7.64	9.22	28.70	28.70		7.97
177	Hof	75.85	10.97	52.0	0.09	79.01	9.63	10.87	0.55	1.815	94.4	2.05	5.31	5.31	1.60	2.48	5.31	5.31	0.29	2.73
178	Bayreuth	95.98	7.74	55.4		95.98	7.74	7.46												
179	Bamberg	108.97	7.94	53.0		106.40	7.94	6.94												
180	Kulmbach	34.90	4.10	50.6	17.27	35.21	3.87	9.90	6.37	0.157	7.9	0.40								
181	Kronach	36.28	3.48	47.8	−11.86	36.57	3.48	8.69	1.77	0.565	27.0	1.41								
182	Coburg	74.05	6.12	55.9	−12.96	75.15	6.12	7.53	0.49	2.047	114.3	2.52								
183	Lichtenfels	36.05	2.68	47.1		36.05	2.68	6.91												
184	Erlangen	173.27	9.86	63.7		166.70	9.86	5.59												
185	Nürnberg	564.65	42.37	62.3		564.65	42.37	6.98												
186	Weißenburg-Gunzenhausen	41.29	2.98	50.7		41.29	2.98	6.73												
187	Ansbach	105.86	6.39	54.0		105.50	6.39	5.71												
188	Neustadt/Aisch	39.73	2.64	50.3	156.96	38.80	2.64	6.38	92.00	0.011	0.5	0.03								
189	Kitzingen	41.20	2.03	50.5		39.90	2.05	4.89												
190	Würzburg	156.25	8.30	52.8		154.90	8.30	5.08												
191	Schweinfurt	92.16	5.02	55.7	−4.92	88.50	6.24	6.58	0.80	1.243	69.3	1.31								
192	Haßfurt	40.06	2.57	51.8	−4.56	38.20	2.61	6.40	2.50	0.400	20.7	0.98								
193	Bad Neustadt/Saale	38.85	3.79	50.9	−1.16	38.85	3.79	8.89	0.72	1.381	70.2	3.24								
194	Bad Kissingen	49.84	4.21	48.5	1.32	49.84	4.21	7.78	1.31	0.761	36.9	1.41								
195	Lohr am Main	59.43	3.16	58.8		57.90	3.16	5.18												
196	Aschaffenburg	178.86	11.68	54.5		172.40	11.68	6.34												
197	Donauwörth-Nördlingen	66.50	2.81	55.5		65.50	2.81	4.12												
198	Dillingen	38.91	1.94	53.6		38.70	1.94	4.77												
199	Günzburg	57.52	3.41	59.9		57.00	3.41	5.65												
200	Augsburg	298.31	16.63	59.0		297.40	16.63	5.29												
201	Memmingen	90.73	4.46	50.8		89.60	4.46	4.74												
202	Kaufbeuren	81.16	3.81	53.2		80.90	3.81	4.50												
203	Kempten	106.05	5.51	50.0		106.05	5.51	4.94												
204	Lindau	36.26	1.55	52.0		36.26	1.55	4.10												

Table 3.1: 2004-forecast for 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				Joint budget of East and West			
							$\boldsymbol{u}$	$\boldsymbol{n}$		$\boldsymbol{j}$	$\boldsymbol{g}$	$\boldsymbol{d}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$
		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	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	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			79.50	71.55
206	Greifswald	68.71	19.68	38.4	15.37	68.71	17.75	20.53	19.79	0.051	1.9	0.06							6.98	
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				7.37	
208	Bergen	30.07	8.28	36.1	37.76	30.07	7.73	20.45	37.76	0.026	1.0	0.07							28.71	
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			27.08	29.26
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			66.06	63.82
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			49.39	1.72
214	Schwerin	105.09	22.11	44.1	2.17	109.52	20.05	15.47	8.79	0.114	5.0	0.09								3.43
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	49.42	49.42	22.70	26.58
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			33.73	33.73	8.21	10.67
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			33.79	34.89
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			61.20	66.44
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				21.32
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			28.29	30.64
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				36.09	0.14
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			52.73	54.95
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				23.12	
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				29.47	
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				24.83	
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			53.71	44.89
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			109.83	99.48
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			31.99	
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			73.77	
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			76.03	
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 3.1: 2004-forecast for 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				Joint budget of East and West			
						$\boldsymbol{u}$	$\boldsymbol{n}$		$\boldsymbol{j}$	$\boldsymbol{g}$	$\boldsymbol{d}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$	$\boldsymbol{x}_{1:0:0}$	$\boldsymbol{x}_{0:1:0}$	$\boldsymbol{x}_{0:0:1}$	$\boldsymbol{x}_{2:1:7}$
	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	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	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					19.18	27.97
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			21.06	22.95
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	73.24	73.24	26.93	33.19
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			30.61	32.54
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	53.01	53.01	25.11	29.15
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			23.34	34.45
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	50.17	50.17	16.59	21.94
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			54.87	57.78
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			28.77	36.44
252 Gotha	64.94	13.18	42.8	6.16	63.68	13.18	17.15	8.37	0.120	5.1	0.16							21.56	28.99
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			51.49	53.77
254 Sonneberg	27.24	4.66	37.6	9.57	26.35	4.66	15.03	9.57	0.104	3.9	0.34							9.74	10.85
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	68.53	68.53	27.69	34.20
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	51.14	51.14	21.38	25.75
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			57.54	61.17
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			58.77	68.57
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			38.39	43.60
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			71.80	80.77
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	268.39			67.37
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			71.27	89.52
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			33.87	55.37
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	350.35	350.35		
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			58.76	10.51
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	162.45		45.54	68.56
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			80.45	44.43
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			66.56	24.38
West Germany	32045.70	2531.20	59.2		31490.37	2520.09	7.41					282.66	282.66	282.66	282.66	775.60	1206.45	43.90	245.75
East Germany	7212.18	1897.13	44.0		7282.40	1717.64	19.08					1653.38	1653.38	1653.38	1653.38	1160.44	729.59	1892.14	1690.29
Whole Germany	39257.88	4428.32	56.4		38772.77	4237.73	9.85					1936.04	1936.04	1936.04	1936.04	1936.04	1936.04	1936.04	1936.04

Chemniz, and Dresden). In the given case it means at least 134 jobs for 1 Mio EUR aid. In these regions the unemployment is eliminated completely, which corresponds to full-height white gaps in the upper plot. The last subsidized region is 265 (Plauen) where the threshold aid efficiency 134 jobs for 1 Mio EUR aid is just attained. 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 average unemployment by 3% and increases GDP by almost 11 Bio EUR. Only the taxes from this gain would not only cover the aid expenditures $B = 1653$ Mio EUR but also contribute to the state budget. On the other hand, the unemployment variance increases from 12.9 to almost $90\%^2$, which is hardly acceptable.

- The second model has the target weight ratio 0 : 1 : 0, reducing the consideration to the second target **GDP gain**. The model also selects 15 of 67 regions, but now with the best productivity-to-'job-cost' ratio. In the given case it means at least 5.2 Mio EUR of GDP gain from 1 Mio EUR aid (= better than 520%-returns). The selected regions can be visually recognized in the second plot by the full-height white gaps, meaning complete elimination of unemployment in the regions selected. The threshold 520%-returns is attained in the 251th region Meiningen, where the remaining aid is not sufficient to completely exhaust the unemployment (the white gap is small).

  The effect of this policy is very similar to the one obtained from the maximization of employment discussed previously. The GDP gain and the average unemployment are insignificantly higher, by only 135 Mio EUR and 0.1%, respectively. The unemployment variance is also almost the same, differing in $0.2\%^2$. It is also remarkable that 13 of the 15 regions selected coincide in both models. This means that **productive regions are 'cheap' for grant-givers**. Highly competitive industries can create new jobs with little aid.

- The third model has the target weight ratio 0 : 0 : 1. The consideration is thereby reduced to the third target **Unemployment equalization**. 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 optimization is depicted in the third plot of Figure 3.1, where the equalization is visually distinct.

  The available aid suffices to reduce the unemployment variance from 12.9 to $4.2\%^2$, On the other hand, this policy results in a rather modest decrease in the average unemployment by only 0.8% and a contribution to GDP 3.1 Bio EUR (188%-return from the aid).

Summing up what has been said, neither one-target model gives an acceptable solution. Since the difference between models 1–2 and 3 is large, a combination of targets looks most natural. A sample of compromise policy is provided by the fourth model illustrated with the fourth plot in Figure 3.1. We comment on this model in the next section.

Table 3.2:

Unemployment, in % GDP gain, in Mio EUR Unemployment variance, in $\%^2$	resulting from optimal aid distribution for 2004

	Forecast with no aid	Separate budgets of East and West Germany					Joint budget of East and West Germany				
		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	Aid distribution with target ratio 2:0.5:7.5	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	Aid distribution with target ratio 2:0.5:7.5
West Germany	7.4 0 7.0	7.0 6684 8.5	7.0 6702 8.2	7.3 2775 4.5	7.1 4485 4.8	7.2 4190 4.7	6.7 12740 10.1	6.5 15589 9.8	7.4 524 5.9	7.1 6007 5.6	7.1 4849 5.5
East Germany	19.1 0 12.9	16.1 10747 89.5	16.2 10872 89.3	18.3 3112 4.2	17.1 7672 14.7	17.3 6926 11.7	16.9 8041 68.4	17.7 5401 60.4	17.2 7104 20.0	17.0 7684 28.3	17.0 7693 27.0
Whole Germany	9.9 0 41.7	8.9 17430 46.6	8.9 17574 45.3	9.6 5887 31.5	9.2 12157 32.3	9.3 11115 31.6	8.8 20781 50.0	8.8 20990 50.6	9.4 7627 25.3	9.1 13691 28.0	9.2 12542 27.2
Total aid, in Mio. EUR											
West Germany		283	283	283	283	283	776	1206	44	312	246
East Germany		1653	1653	1653	1653	1653	1160	730	1892	1624	1690
Whole Germany		1936	1936	1936	1936	1936	1936	1936	1936	1936	1936

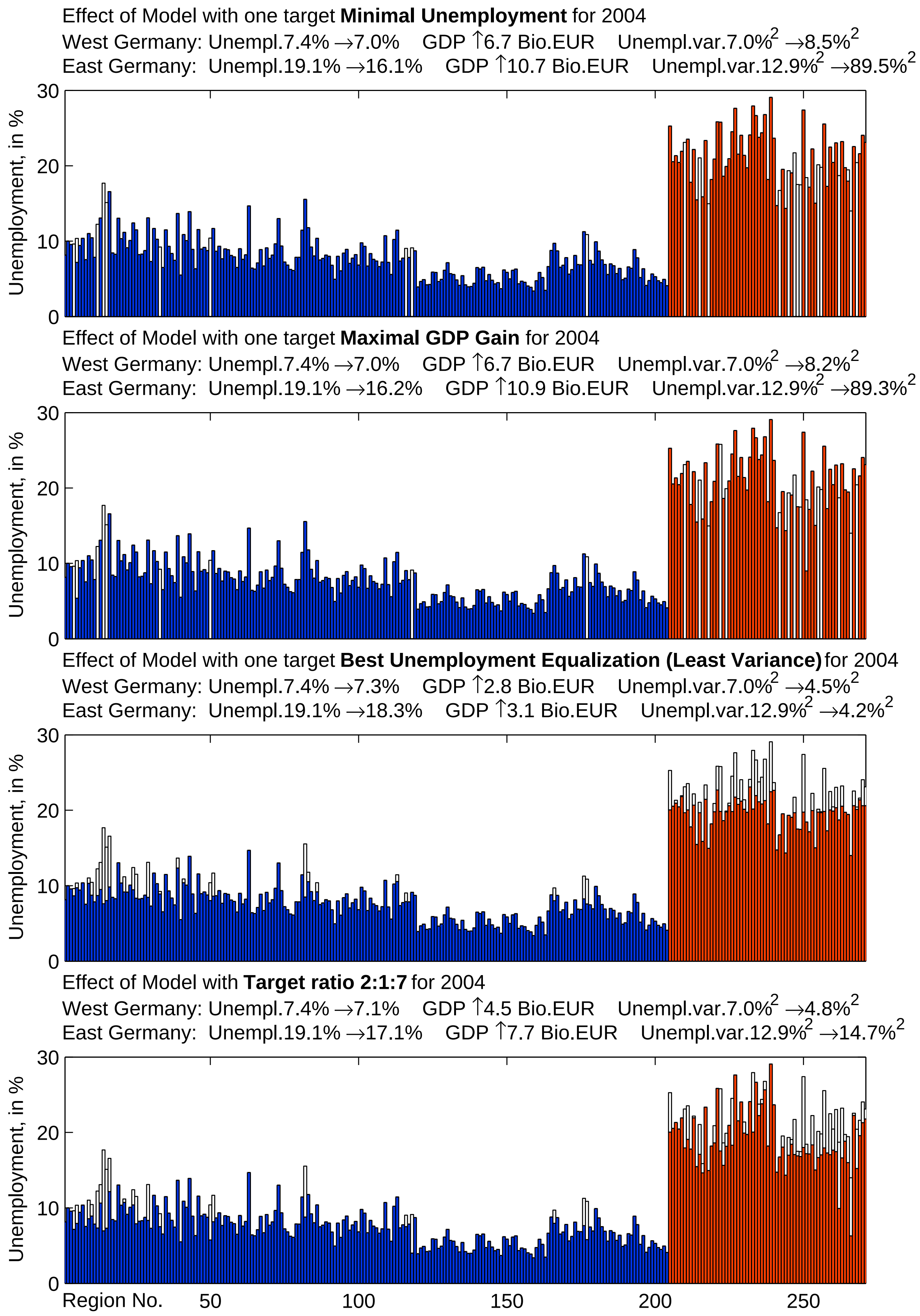

Figure 3.1: Effects of aid distribution with a separate budget for West and East Germany

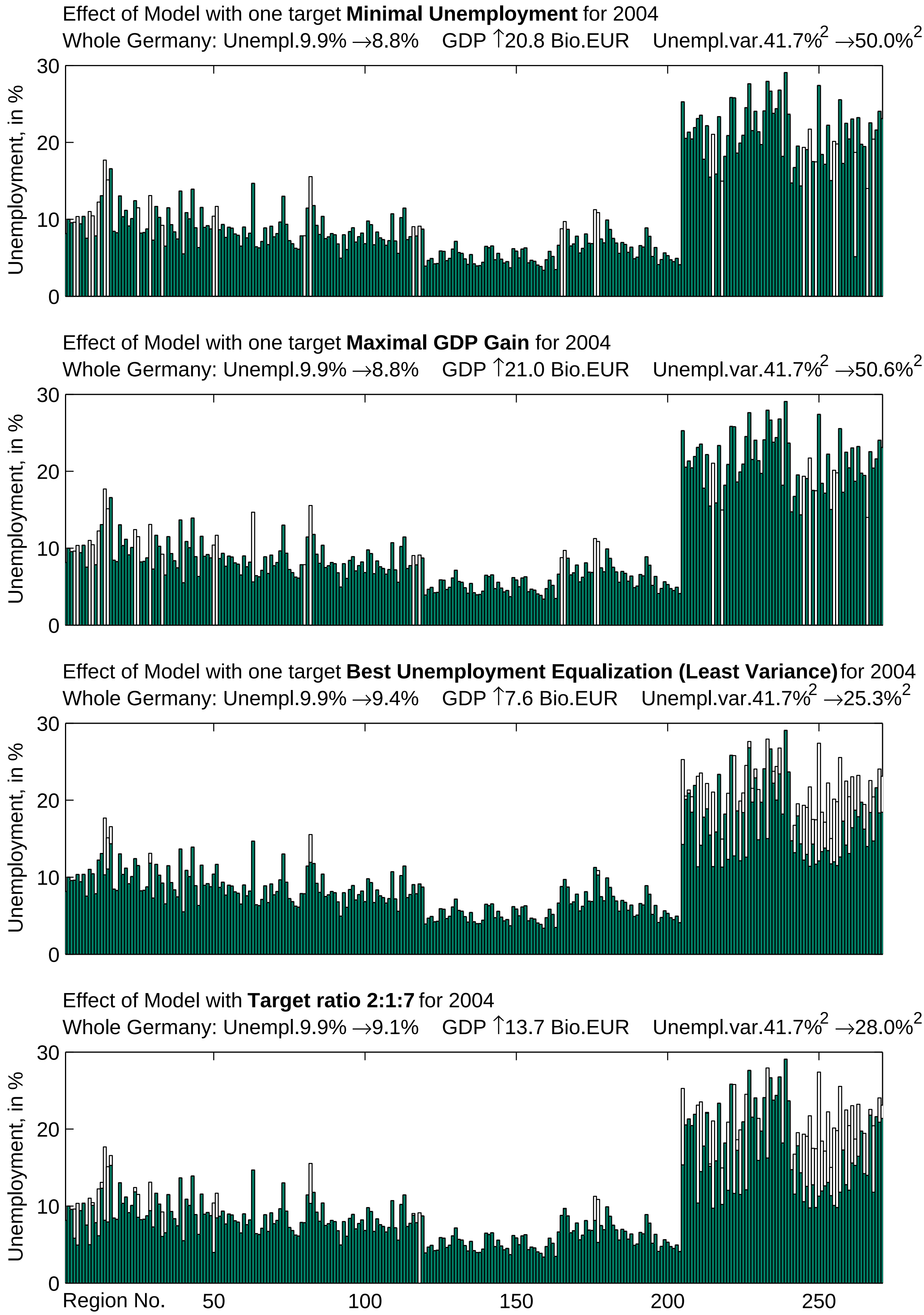

Figure 3.2: Effects of aid distribution with a joint budget for West and East Germany

3.2 Multiple-target optimization

As seen from Table 3.2 and the fourth plot in Figure 3.1, the policy obtained for the target weight ratio 2 : 1 : 7 is a real compromise between the policies determined by single targets. It results in 17.1% unemployment which is by 1.0% more than under the model with single target 'Employment' but still 2.0% better than with no aid. Besides it promises the gain in GDP almost 7.7 Bio EUR, which is 4.5 Bio EUR more than under the equalization criterion only. On the other hand, the unemployment variance is 14.7% which is clearly better than $90\%^2$ under the optimization by employment or GDP criterion.

The only weakness of this solution is a minor increase in the unemployment variance comparing with the net forecast for 2004, from 12.9 to $14.7\%^2$, see Table 3.2. It does not meet the destination of the aid, equalizing regional unemployment. The solution can be easily fitted to this goal by adjusting the target weight ratio. Making the third target 0.5 units 'heavier' and running the model with weights 2:0.5:7.5, we obtain an other optimal solution with the decrease in the unemployment variance from the predicted 12.9 to $11.7\%^2$, see Table 3.2.

3.3 Triangle of priorities and target maps

The target weights a, b, c are too abstract decision parameters if they are not linked to practical implications. The effect of target weights on the optimal East German regional policy is displayed in Table 3.3 and in the associated Figure 3.3.

The **triangle of priorities** in Table 3.3 shows triplets of effects, national unemployment rate, GDP gain, and the regional unemployment variance for all combinations of target weights to within 0.1. The target weights a, b, c are normalized in the sense that $a+b+c=1$, meaning that they are 'the percentage of importance'. 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 arrow stemming from 0.2 in the foot row of the table.

Consider the head element in the table cells, the national unemployment. It constitutes a certain 'relief' on the triangle of priorities. The map of this relief and the relief itself are depicted in the upper section of Figure 3.3.

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 3.3. Similarly, the bottom section of Figure 3.3 show the map and the relief of the foot element of the table cells.

The maps and reliefs in Figure 3.3 illustrate the triple effect of moving over 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 reliefs are not linear, and their increase or decrease are not directly conditioned by each other. It gives a room for finding compromises. For instance, a relatively low unemployment and high GDP gain are compatible with a relatively low unemployment variance.

3.4 Budgeting the optimal regional policy

Usually decisions are made with respect to expected results under a certain budget flexibility. If the expectations are favorable then the initially intended budget can be somewhat increased. If the predictions are pessimistic, the budget intended can be drastically cut. Planning a regional policy is not an exception from this rule.

In principle one can predict the triple effect of the optimal regional policy for all combinations of target weights and budgets. It is not however necessary, because the effects from the optimization with target 'Employment' or with target 'GDP gain' are very close. Therefore, it suffices to retain only one of these targets and to scan over the weight ratios Employment : Unemployment equalization, and over variable budgets.

Consider normalized ratios $a : c$, $a+c = 1$. Then c uniquely determines a, implying that ratios $a : c$ require one table dimension. Variable budgets require another dimension, and we obtain Table 3.4. It is arranged similarly to Table 3.3, with cells displaying the triplet effect of the optimal regional policy and, additionally an optional indicator. Besides, the horizontal axis is now devoted to the total investment in the regional policy (= budget constraint) and the table is not triangular, but rectangular.

Again, the first three elements of the cells determine three reliefs depicted together with their maps in the associated Figure 3.4 These reliefs show which employment, GDP, and equalization effects can be obtained from increasing the budget of the regional policy. The fourth element of the cell, 'Profitability', estimates the pure profit of the state from the regional policy.

For instance, suppose that the GDP effect from 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 2001), or 1.173 Mio EUR. Then the pure 'profit' of the state is $1.173 - 1 = 0.173$ Mio EUR, or 17.3%. These figures constitute the fourth element of the cells. Since the relief of the GDP exhibits decreasing marginal returns from the budget increment, budgeting is getting no longer profitable beyond certain limits.

It should be noted that due to the linearity of our prediction model, the forecast is getting less reliable as we deviate from some moderate policy. This means that neither extreme ratios of target weights, nor very limited or, on the contrary, generous budgets can be accurately processed by the model. Then the model results should be interpreted rather as general trends.

3.5 Optimal policy for West and for whole Germany

The case of West Germany with a separate budget $B = 282.66$ Mio EUR aid and its $m = 204$ regions, or the case of whole Germany with a joint budget $B = 1936.04$ Mio EUR aid and totally $m = 271$ regions does not differ essentially from the case of East Germany discussed in detail. The effects of optimal regional policies are displayed in the corresponding sections of Table 3.2. Their interpretation is similar to what has been performed for East Germany.

The practical implications of target weights are shown in triangular Tables 3.5 and 3.7. Similarly to the case of East Germany, these tables are coupled with Figures 3.5 and 3.7, respectively. The figures display the maps and reliefs of the optimization effects on the triangle of priorities.

Table 3.3: [Unemployment, in %
GDP gain, in Mio EUR
Unemployment variance, in $\%^2$] optimized on the triangle of priorities for East Germany 2004

Equalization priority	GDP 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

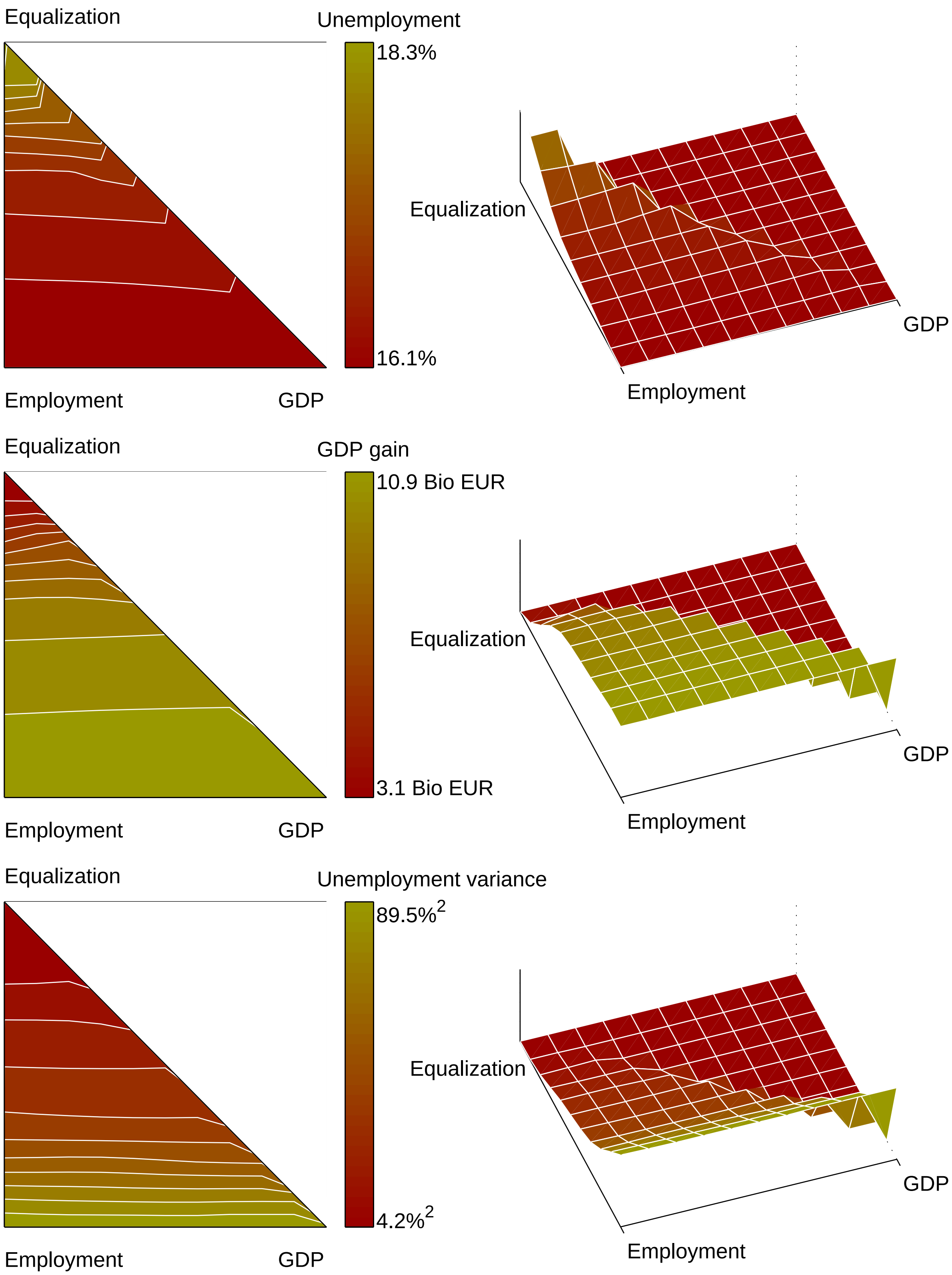

Figure 3.3: The triangle of priorities with maps and reliefs of three target variables optimized for East Germany 2004

Table 3.4:

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

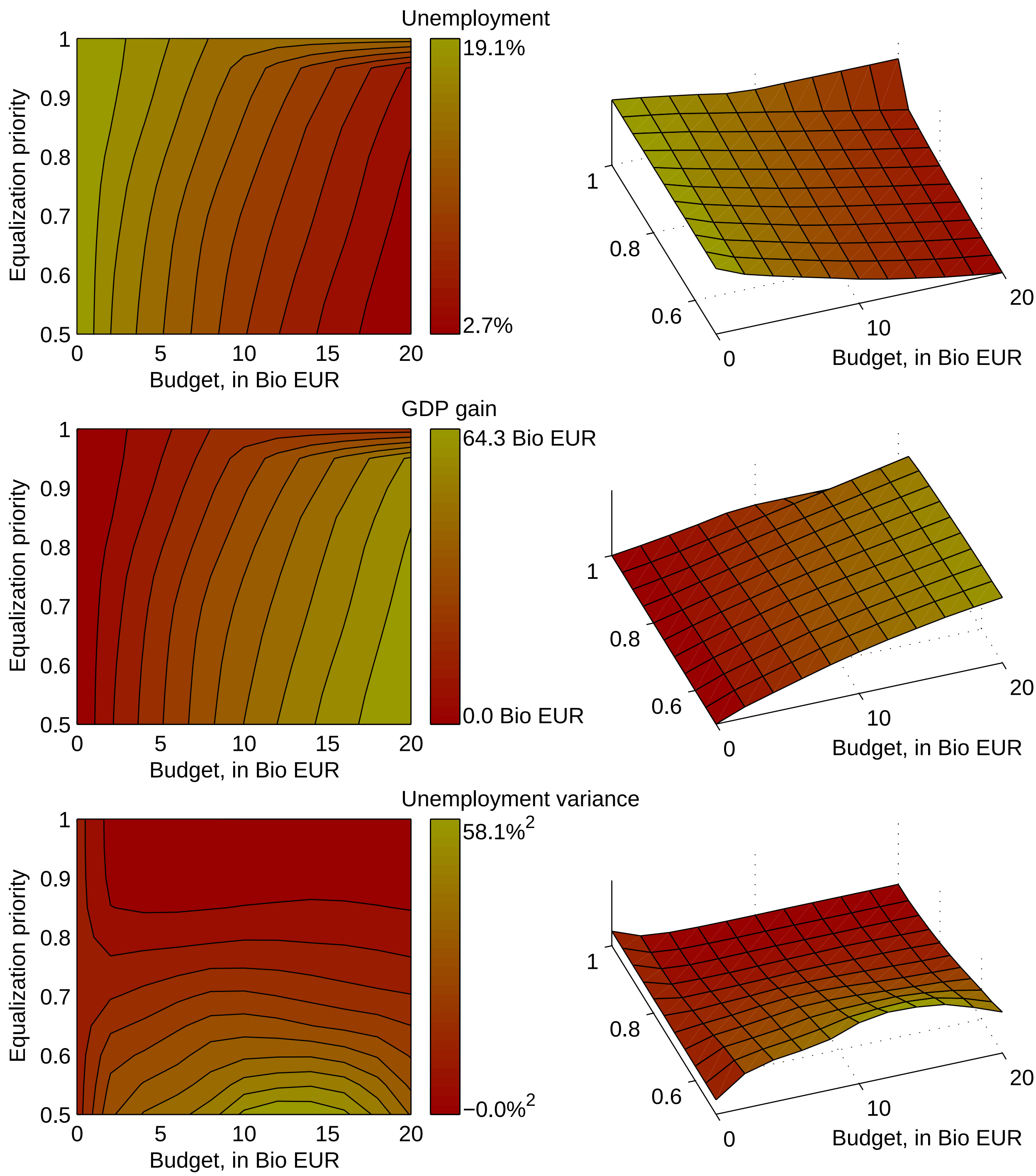

Figure 3.4: Three target variables optimized under variable budget for East Germany 2004

Table 3.5: [Unemployment, in %
GDP gain, in Mio EUR
Unemployment variance, in $\%^2$] optimized on the triangle of priorities for West Germany 2004

Equalization priority	GDP priority 0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
1	7.3 2775 4.5										
0.9	7.2 3307 4.5	7.2 3310 4.5									
0.8	7.2 3914 4.6	7.2 3910 4.6	7.2 3905 4.6								
0.7	7.1 4491 4.8	7.1 4485 4.8	7.2 4480 4.8	7.2 4475 4.8							
0.6	7.1 5161 5.2	7.1 5153 5.2	7.1 5145 5.2	7.1 5137 5.2	7.1 5129 5.2						
0.5	7.1 5781 5.7	7.1 5793 5.7	7.1 5806 5.7	7.1 5818 5.7	7.1 5830 5.7	7.1 5842 5.8					
0.4	7.1 6060 6.0	7.1 6072 6.0	7.1 6084 6.1	7.1 6096 6.1	7.1 6108 6.1	7.1 6120 6.1	7.1 6132 6.1				
0.3	7.0 6302 6.5	7.0 6309 6.5	7.0 6315 6.5	7.0 6321 6.5	7.0 6328 6.5	7.0 6334 6.5	7.0 6339 6.5	7.0 6344 6.5			
0.2	7.0 6526 7.2	7.0 6531 7.2	7.0 6537 7.2	7.0 6542 7.2	7.0 6548 7.2	7.0 6552 7.2	7.0 6556 7.2	7.0 6560 7.2	7.0 6561 7.2		
0.1	7.0 6679 8.0	7.0 6679 7.9	7.0 6679 7.9	7.0 6678 7.9	7.0 6678 7.9	7.0 6677 7.9	7.0 6677 7.9	7.0 6677 7.9	7.0 6676 7.9	7.0 6674 7.9	
0	7.0 6684 8.5	7.0 6684 8.5	7.0 6684 8.5	7.0 6702 8.2	7.0 6702 8.2	7.0 6702 8.2	7.0 6702 8.2	7.0 6702 8.2	7.0 6702 8.2	7.0 6702 8.2	7.0 6702 8.2
Employment priority	↖ 1	↖ 0.9	↖ 0.8	↖ 0.7	↖ 0.6	↖ 0.5	↖ 0.4	↖ 0.3	↖ 0.2	↖ 0.1	↖ 0

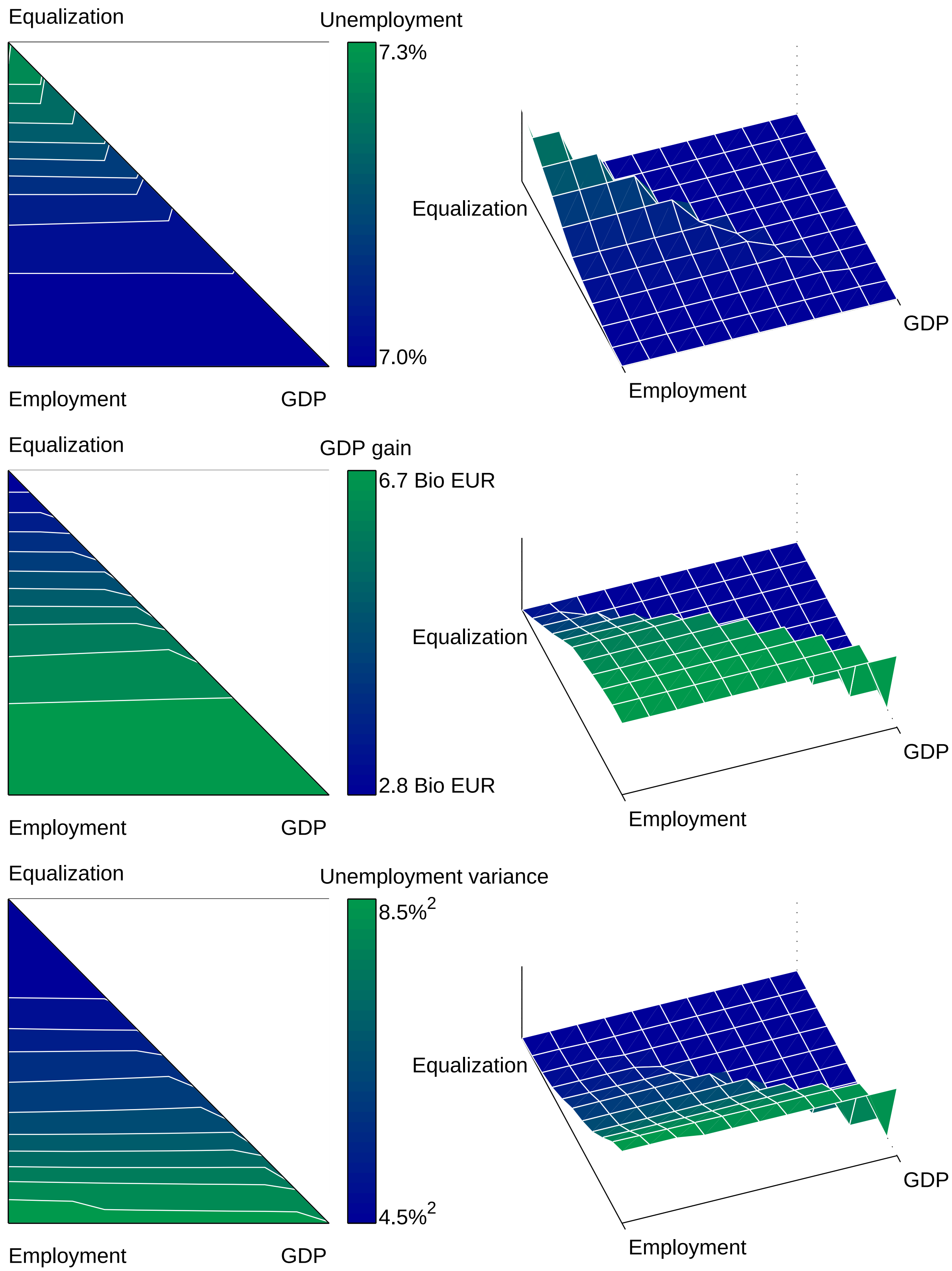

Figure 3.5: The triangle of priorities with maps and reliefs of three target variables optimized for West Germany 2004

Table 3.6:

Unemployment, in % GDP gain, in Mio EUR Unemployment variance, in $\%^2$ Profitability, in %	under variable budget for West Germany 2004

Equalization Priority	Investment in regional policy, in Mio EUR										
	0	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000
1	7.4	6.8	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	0	10973	16990	16990	16990	16990	16990	16990	16990	16990	16990
	7.0	2.4	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
		114.5	66.1	10.7	−17.0	−33.6	−44.6	−52.5	−58.5	−63.1	−66.8
0.95	7.4	6.7	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
	0	11676	19945	20219	20219	20219	20219	20219	20219	20219	20219
	7.0	2.5	2.1	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
		128.3	95.0	31.8	−1.2	−20.9	−34.1	−43.5	−50.6	−56.1	−60.5
0.9	7.4	6.7	6.2	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
	0	12387	20740	23806	23806	23806	23806	23806	23806	23806	23806
	7.0	2.5	2.2	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
		142.2	102.7	55.1	16.4	−6.9	−22.4	−33.5	−41.8	−48.3	−53.5
0.85	7.4	6.7	6.2	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
	0	13087	21629	27815	27815	27815	27815	27815	27815	27815	27815
	7.0	2.6	2.3	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
		155.9	111.4	81.3	35.9	8.8	−9.4	−22.3	−32.0	−39.6	−45.6
0.8	7.4	6.6	6.1	5.7	5.6	5.6	5.6	5.6	5.6	5.6	5.6
	0	13816	22629	30794	31423	31423	31423	31423	31423	31423	31423
	7.0	2.8	2.6	3.6	3.7	3.7	3.7	3.7	3.7	3.7	3.7
		170.1	121.2	100.7	53.6	22.9	2.4	−12.2	−23.2	−31.7	−38.6
0.75	7.4	6.6	6.1	5.6	5.5	5.5	5.5	5.5	5.5	5.5	5.5
	0	14643	23762	31666	33540	33540	33540	33540	33540	33540	33540
	7.0	3.0	2.9	3.8	4.3	4.3	4.3	4.3	4.3	4.3	4.3
		186.3	132.3	106.4	63.9	31.1	9.3	−6.3	−18.0	−27.1	−34.4
0.7	7.4	6.5	6.0	5.6	5.4	5.4	5.4	5.4	5.4	5.4	5.4
	0	15414	24727	32422	35242	35242	35242	35242	35242	35242	35242
	7.0	3.3	3.2	4.1	4.9	4.9	4.9	4.9	4.9	4.9	4.9
		201.3	141.7	111.3	72.2	37.8	14.8	−1.6	−13.9	−23.4	−31.1
0.65	7.4	6.5	6.0	5.5	5.3	5.3	5.3	5.3	5.3	5.3	5.3
	0	16015	25557	33229	36769	36769	36769	36769	36769	36769	36769
	7.0	3.6	3.6	4.5	5.6	5.6	5.6	5.6	5.6	5.6	5.6
		213.1	149.8	116.5	79.7	43.8	19.8	2.7	−10.1	−20.1	−28.1
0.6	7.4	6.4	5.9	5.5	5.3	5.3	5.3	5.3	5.3	5.3	5.3
	0	16681	26364	33909	38305	38305	38305	38305	38305	38305	38305
	7.0	4.0	4.1	4.9	6.5	6.5	6.5	6.5	6.5	6.5	6.5
		226.1	157.7	121.0	87.2	49.8	24.8	7.0	−6.4	−16.8	−25.1
0.55	7.4	6.4	5.9	5.5	5.2	5.2	5.2	5.2	5.2	5.2	5.2
	0	17425	27069	34602	39606	39606	39606	39606	39606	39606	39606
	7.0	4.6	4.6	5.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
		240.7	164.6	125.5	93.6	54.9	29.1	10.6	−3.2	−14.0	−22.6
0.5	7.4	6.4	5.8	5.4	5.2	5.1	5.1	5.1	5.1	5.1	5.1
	0	18029	27769	35167	40074	40524	40524	40524	40524	40524	40524
	7.0	5.2	5.2	5.9	7.9	8.3	8.3	8.3	8.3	8.3	8.3
		252.5	171.4	129.2	95.9	58.4	32.0	13.2	−1.0	−12.0	−20.8

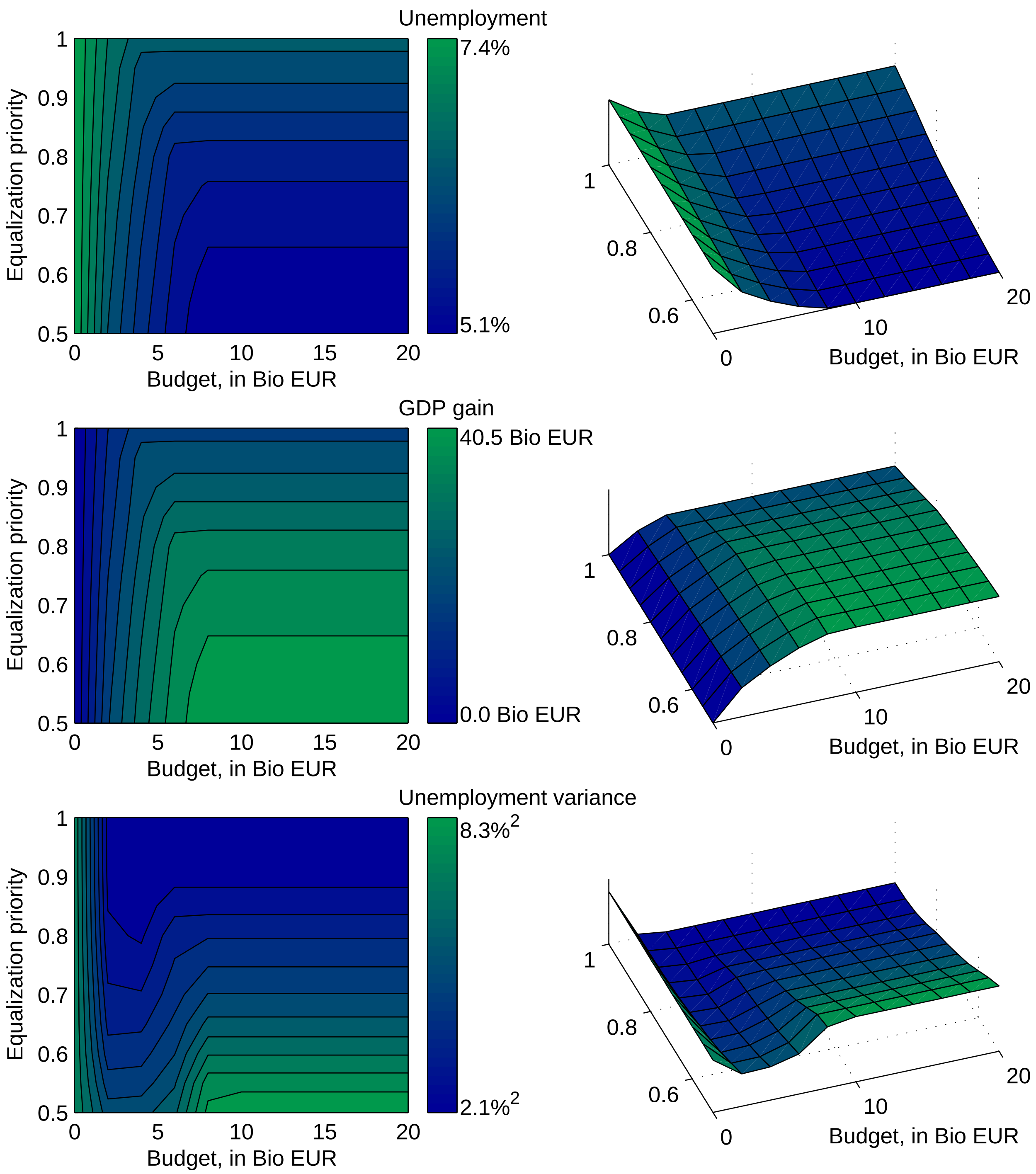

Figure 3.6: Three target variables optimized under variable budget for West Germany 2004

Table 3.7: Unemployment, in %
GDP gain, in Mio EUR
Unemployment variance, in $\%^2$ optimized on the triangle of priorities for whole Germany 2004

Equalization priority	GDP priority 0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
1	9.4 7627 25.3										
0.9	9.4 8485 25.4	9.4 8371 25.4									
0.8	9.3 11096 26.4	9.3 11051 26.3	9.3 11007 26.3								
0.7	9.1 13612 27.9	9.1 13691 28.0	9.1 13755 28.0	9.1 13809 28.0							
0.6	9.0 15870 30.2	9.0 16003 30.3	9.0 16127 30.4	9.0 16188 30.4	9.0 16207 30.5						
0.5	9.0 17430 32.5	9.0 17452 32.5	9.0 17476 32.5	9.0 17500 32.5	9.0 17529 32.5	9.0 17557 32.5					
0.4	8.9 18454 35.0	8.9 18495 35.0	8.9 18541 35.0	8.9 18588 35.0	8.9 18636 35.1	8.9 18683 35.2	8.9 18734 35.3				
0.3	8.9 19512 38.6	8.9 19563 38.6	8.9 19617 38.7	8.9 19671 38.8	8.9 19716 38.8	8.9 19754 38.9	8.9 19796 39.0	8.9 19844 39.2			
0.2	8.8 20166 42.5	8.8 20215 42.4	8.8 20261 42.4	8.8 20300 42.4	8.8 20345 42.4	8.8 20363 42.3	8.8 20372 42.2	8.9 20400 42.3	8.9 20435 42.5		
0.1	8.8 20612 47.1	8.8 20663 47.3	8.8 20685 47.2	8.8 20709 47.1	8.8 20733 47.1	8.8 20770 47.1	8.8 20799 47.1	8.8 20830 47.1	8.8 20875 47.3	8.8 20885 47.4	
0	8.8 20781 50.0	8.8 20781 50.0	8.8 20781 50.0	8.8 20781 50.0	8.8 20781 50.0	8.8 20858 49.9	8.8 20949 50.5	8.8 20962 50.6	8.8 20962 50.6	8.8 20962 50.6	8.8 20990 50.6
Employment priority	↖ 1	↖ 0.9	↖ 0.8	↖ 0.7	↖ 0.6	↖ 0.5	↖ 0.4	↖ 0.3	↖ 0.2	↖ 0.1	↖ 0

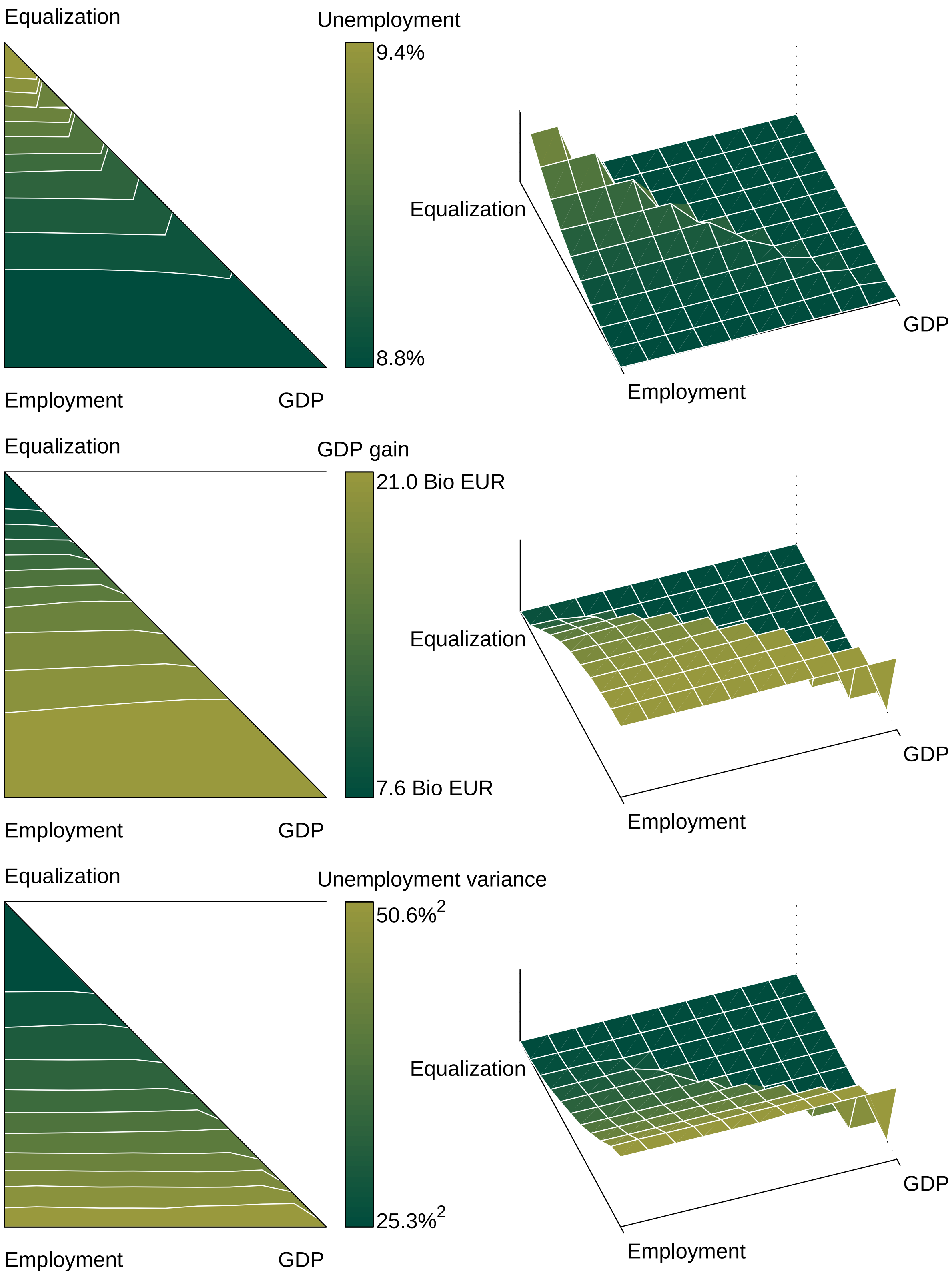

Figure 3.7: The triangle of priorities with maps and reliefs of three target variables optimized for whole Germany 2004

Table 3.8: Unemployment, in %; GDP gain, in Mio EUR; Unemployment variance, in $\%^2$; Profitability, in % under variable budget for whole Germany 2004

Equalization Priority	Investment in regional policy, in Mio EUR										
	0	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000
1	9.9	9.4	9.1	8.9	8.6	8.4	8.1	7.8	7.5	7.2	6.9
	0	7783	12624	17264	22097	27466	32912	38210	43913	50201	56993
	41.7	25.0	17.8	12.7	9.0	6.4	4.6	3.3	2.5	2.0	1.7
		52.2	23.4	12.5	8.0	7.4	7.2	6.7	7.3	9.0	11.4
0.95	9.9	9.4	9.1	8.8	8.6	8.3	7.9	7.7	7.4	7.0	6.7
	0	8142	13354	18427	23892	29790	35762	41426	47423	54227	61026
	41.7	25.0	17.9	12.8	9.1	6.5	4.7	3.5	2.7	2.2	1.9
		59.2	30.5	20.1	16.8	16.5	16.5	15.7	15.9	17.8	19.3
0.9	9.9	9.4	9.0	8.7	8.4	8.1	7.8	7.5	7.2	6.8	6.5
	0	8687	14783	20515	26405	32416	38677	45158	51613	58545	65448
	41.7	25.1	18.1	13.2	9.6	6.9	5.2	4.1	3.3	2.9	2.6
		69.8	44.5	33.7	29.1	26.7	26.0	26.1	26.1	27.2	28.0
0.85	9.9	9.3	8.9	8.6	8.3	8.0	7.7	7.3	7.0	6.6	6.3
	0	9824	16754	23023	29260	35449	42037	48716	55849	63070	69972
	41.7	25.5	18.7	13.9	10.4	7.8	6.2	5.1	4.5	4.1	3.8
		92.1	63.8	50.0	43.0	38.6	37.0	36.1	36.5	37.0	36.8
0.8	9.9	9.2	8.8	8.5	8.1	7.8	7.5	7.2	6.8	6.5	6.1
	0	11378	19038	25856	32168	38478	45272	52172	59449	66692	73854
	41.7	26.1	19.7	15.1	11.7	9.1	7.5	6.5	6.0	5.6	5.4
		122.4	86.1	68.5	57.2	50.4	47.5	45.7	45.3	44.9	44.4
0.75	9.9	9.2	8.7	8.3	8.0	7.7	7.3	7.0	6.7	6.3	6.0
	0	12826	20988	28424	35061	41785	48895	55785	63015	70133	77230
	41.7	26.9	20.9	16.7	13.4	11.0	9.5	8.5	7.9	7.5	7.2
		150.8	105.2	85.2	71.4	63.4	59.3	55.8	54.0	52.3	51.0
0.7	9.9	9.1	8.6	8.2	7.8	7.5	7.2	6.9	6.5	6.2	5.8
	0	13947	23099	31122	38258	45160	51849	59030	66357	73606	80436
	41.7	27.7	22.4	18.7	15.8	13.5	11.7	10.8	10.3	9.9	9.5
		172.7	125.8	102.8	87.0	76.6	68.9	64.9	62.2	59.9	57.3
0.65	9.9	9.1	8.5	8.1	7.7	7.4	7.1	6.7	6.4	6.0	5.7
	0	15057	25292	33609	40821	47811	54782	62195	69470	76686	82796
	41.7	28.7	24.5	21.1	18.3	15.9	14.3	13.7	13.1	12.7	11.7
		194.4	147.2	119.0	99.5	86.9	78.5	73.7	69.8	66.6	61.9
0.6	9.9	9.0	8.4	8.0	7.6	7.3	6.9	6.6	6.2	5.9	5.6
	0	16264	27009	35520	42710	50118	57434	64855	72255	79491	84816
	41.7	30.0	26.5	23.5	20.4	18.5	17.3	16.7	16.3	15.9	14.2
		218.0	164.0	131.5	108.7	96.0	87.1	81.1	76.6	72.7	65.8
0.55	9.9	9.0	8.4	7.9	7.6	7.2	6.8	6.5	6.1	5.8	5.5
	0	17181	28363	36657	44511	52307	59745	67228	74662	81238	86588
	41.7	31.3	28.5	25.2	22.9	21.5	20.6	20.0	19.6	18.6	17.0
		235.9	177.2	138.9	117.5	104.5	94.7	87.8	82.5	76.5	69.3
0.5	9.9	8.9	8.3	7.9	7.5	7.1	6.7	6.4	6.0	5.7	5.5
	0	17803	29244	37829	46082	54031	61735	69336	76824	82775	87987
	41.7	32.4	30.1	27.3	25.5	24.4	23.9	23.6	23.4	21.4	19.6
		248.0	185.9	146.5	125.2	111.3	101.2	93.6	87.7	79.8	72.0

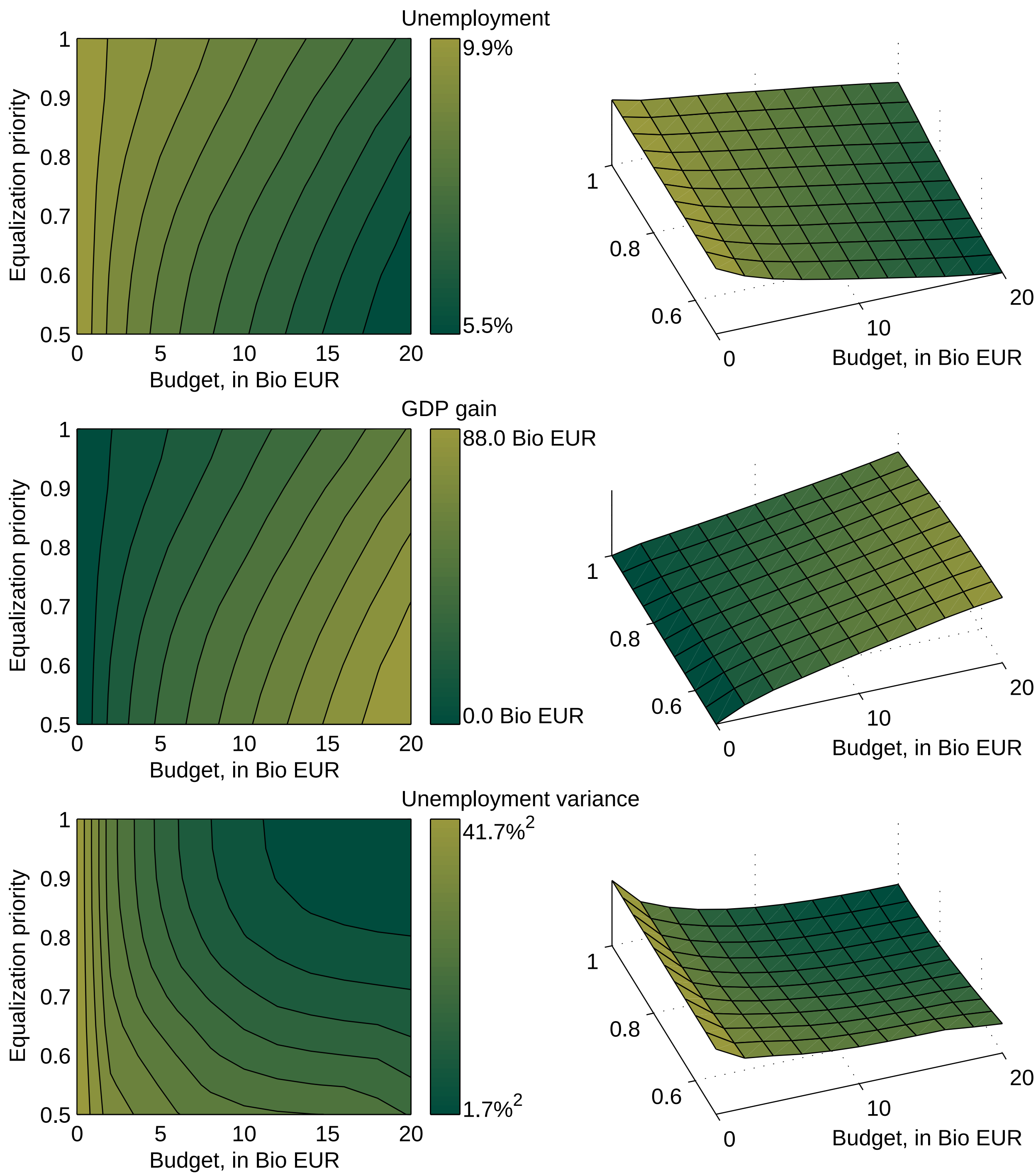

Figure 3.8: Three target variables optimized under variable budget for whole Germany 2004

The budgeting is shown in Tables 3.6 and 3.8. They are also coupled with maps and reliefs in Figures 3.6 and 3.8.

The most remarkable is the **advantage of planning the regional policy for whole Germany rather than for its West and East parts separately**. The row in Table 3.2 devoted to whole Germany distinctly shows better effects in case of joint budget (in full-sized font) than in case of separate budgets (in small font), even with respect to the unemployment equalization. It should be interpreted as a hint to improve the guide-lines for German regional policy.

Chapter 4

Conclusions

4.1 Theoretical implications

1. **(Operational equivalence of employment and GDP criteria)** We have established a high operational dependence of employment and GDP criteria. It is explained by the fact that competitive branches with high productivity can create jobs with little aid. Therefore, supporting competitive industries is the most efficient way of reducing unemployment. Thus, at the level of optimal planning employment and GDP criteria are almost equivalent.

2. **(Importance of equalization criterion)** An extreme priority for unemployment reduction (= economic development) implies an unacceptable variance of regional unemployment rates. If implemented, this would destroy the regional structure, cause uncontrollable migrations, etc. Therefore, equalization of regional unemployment should remain in focus. Besides, it guarantees the reliability of the model. Disregarding the equalization criterion results in disproportions which lead away from the domain where forecasts remain accurate.

3. **(Reduction of three-dimensional criterion space to two dimensions)** The last two items mean that the real planning space is not triangular, with vertices Employment, Economic Growth, and Regional Equalization, but a one-dimensional segment with alternative vertices Employment (= Economic Growth) and Regional Equalization. In other words, the planning triangle is folded into a segment.

4. **(Negative consequences of 'overequalizing' regions)** Exaggerating the importance of equalization is unfavorable for the competitive standing of the national economy. 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. It reduced the competitiveness of German industry and caused high unemployment. Generally, consideration of West and East Germany jointly is more efficient.

5. **(Regional policy as a profitable enterprize)** Besides direct effects on unemployment, GDP, and regional equalization, the model traces the returns from subsidizing regions in the form of taxes on additional production due to additional jobs. It allows to consider regional budgeting as a national enterprize and to evaluate it from

the viewpoint of profitability.

4.2 Possible technical improvements

1. **(Model flexibility)** The bottle-neck of the model is the reliability of econometric predictions and the accuracy of source data. Therefore, the model is designed to import external data which can be more specific or exhausting. Depending on data and goals, the model can also be adjusted to other targets and constraints, or, for instance, to another target year or period.

2. **(Cross-effects from subsidizing neighboring regions)** It is also possible to approximately take account of effects from subsidizing neighboring regions. It can be achieved by allowing the matrix $\boldsymbol{D}$ to contain elements other than on its main diagonal (= which are decrements in the regional unemployment rates resulting from 1 Mio EUR aid to the region). 'Neighboring' elements to the main diagonal of $\boldsymbol{D}$ serve for accounting the effect from subsidizing the neighboring regions in the equation $\boldsymbol{y} = \boldsymbol{n} - \boldsymbol{D}\boldsymbol{x}$. It should be emphasized that in our case we can consider at most six neighboring regions. Indeed, with eight years observations we can determine the intercept, and 7 coefficients associated with regions.

3. **(Adding target variables)** As for target variables, the model can incorporate, for instance, the infrastructure index as the fourth target variable. Then the triangle of priorities turns into a pyramid, the tables operate with quadruplets of effects instead of triplets, and figures will have four reliefs instead of three. The rectangular budget table will turn into a three-dimensional 'cubic' table.

4. **(Adjusting restrictions)** As for restrictions, the regional unemployment rate can be limited, say, to 3% from the bottom. It will save a fraction of the budget and channel the aid to the regions which otherwise receive no subsidies. Besides, restrictions can be individually fitted to particular regions rather than to be equal for all. For instance, Berlin as capital and Leipzig as candidate host of Olympic Games can get some privileges.

Chapter 5

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