An OR Model for Optimizing Regional Labour Market Policy

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Abstract. A decision aid for optimizing regional labour market policy with a user-friendly computer interface is developed. The distribution of subsidies among 271 German regions is considered as an optimization problem with three targets: (1) equalization of regional unemployment rates, (2) minimization of unemployment, and (3) maximization of GDP, subject to budget constraints and some administrative restrictions. The analysis of a three-year period reveals that the results obtained for 6 Bio EUR could be attained for only 241 Mio EUR (= 4% of the actual budget). Such a bad implementation of active labour market policies can be the cause of their low efficiency often misinterpreted as their uselessness. Among other things, it is shows that tax returns from the additional GDP due to jobs subsidized can transform regional policy into a profitable governmental enterprise. In: Shehadi K (ed). Proceedings of the 1st International Conference on Applied Operational Research – ICAOR (2008), pp 151–163. Lecture Notes in Management Science Vol. 1. ISSN 2008-0050.

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1 Introduction

The German labour market is divided into 271 regions, 204 in West Germany and 67 in East Germany. European grants of the Structural Fund 'Objective I' [5] contribute to the German governmental program for equalizing regional unemployment. The goal is to bring it down to the national average by creating new and safeguarding existing jobs [4, 10], which also contributes to reducing the general unemployment and to increasing GDP.

The European employment policy restricts the regions to be supported to 23.4% of the total population [3]. During the control period 1994–2002 all eligible regions received yearly about 2.0–2.8 Bio EUR; West Germany received about 250–280 Mio, about 1/9, and East Germany — 2.0–2.5 Bio, 8/9 of the total. All
East German regions are eligible to receive the aid, while the list of eligible West German regions is reconsidered every year; see Figure 1.

In the given paper we develop a decision model for redistributing the aid among eligible regions in East and West Germany with respect to three targets:

- (first priority) equalize regional unemployment rates, that is, minimize the variance of regional unemployment rates,

\[ \text{Var}(U) \text{ minimized} \]

\[ U_i \text{ is the unemployment rate in region } i \]

**Fig. 1.** Subsidized jobs in German labour market regions in 2000-2002. Source: Bundesamt für Wirtschaft und Ausfuhrkontrolle (2003)
• (second priority) minimize national unemployment, that is, to subsidize as many jobs as possible, and

• (second priority) maximize GDP growth.

The source data are the regional indicators 1994-2002 available from Bundesamt für Wirtschaft und Ausfuhrkontrolle[1], Bundesanstalt für Arbeit [2], and Statistisches Bundesamt [6]. A data sample for the year 1994 is shown in Table 1. These data are transformed into model variables which are regional estimates for net unemployment rate (as if with no subsidies), productivity (GDP per capita), number of jobs subsidised with one Mio EUR, GDP gain due to the jobs subsidised for one Mio EUR, and decrease in regional unemployment rate due to one Mio EUR aid. Disposing the predicted estimates of regional unemployment and of aid efficiency in the region (how many jobs can be created and which will be the GDP increment) together with relative weights of the three targets one can find the optimal aid distribution.

Table 1. Sample source data 1994 (Bundesamt für Wirtschaft und Ausfuhrkontrolle [1]).

<table>
<thead>
<tr>
<th></th>
<th>Employed</th>
<th>Unemployed</th>
<th>GDP</th>
<th>Aid to the region</th>
<th>Number of permanent jobs subsidised</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ths</td>
<td>Ths</td>
<td>Mio EUR</td>
<td>Mio EUR</td>
<td>Ths</td>
</tr>
<tr>
<td>1 Husum</td>
<td>75.30</td>
<td>4.00</td>
<td>2895</td>
<td>0.560</td>
<td>0.030</td>
</tr>
<tr>
<td>2 Heide</td>
<td>54.70</td>
<td>4.00</td>
<td>2308</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3 Itzehoe</td>
<td>53.50</td>
<td>4.30</td>
<td>2791</td>
<td>0.800</td>
<td>0.130</td>
</tr>
</tbody>
</table>

However, the target weights say little to the policy maker. Therefore, the user interface is designed to display attainable results under different ratios of target weights. The task of the policy maker is thereby reduced to choosing among feasible optimal solutions. The program and the user interface are programmed in MATLAB. Some mathematical details are provided in the Annex, see also [7–9].

2 Analysis of the past practice

Recall that the grant considered is aimed primarily at equalizing regional unemployment rates, and that the programs for West and East Germany are separate, each having its own budget. Let us see what has actually been done and what could be done with the optimization model.

The top plot of Figure 2 depicts the actual deviation of regional unemployment rates from the West and East German means $\mu = 7.45\%$, $18.21\%$, respectively, by the end of the control period 2000–2002. West German regions are numbered 1–204, and East German regions have numbers 205–271. Besides the means, the plot displays the standard deviation of regional unemployment rates: $\sigma = 2.1\%$ for West Germany and $\sigma = 3.12\%$ for East Germany.
The middle plot depicts the equalization of regional unemployment if the grant distribution is optimized with respect to the first-priority target "Unemployment equalization". As one can see, the budget of East Germany (5.36 Bio EUR for 2000–2002) is sufficient to almost perfectly equalize its regional unemployment which standard deviation could be reduced to $\sigma = 0.53\%$ instead of the actual 3.12%. The equalization in West Germany could be also improved (standard deviation $\sigma = 1.87\%$ instead of the actual 2.10%) in spite of a restrictive eligibility of regions and a much tighter budget (0.62 Bio EUR).

**Fig. 2.** Equalization of German regional unemployment in 2000-2002
Fig. 3. Inefficiency of German unemployment equalization in 2000–2002

The bottom plot of Figure 2 depicts the correction of the actual budget distribution to attain the optimum. For instance, Berlin (region 216) received 536.7 Mio EUR but should have not received any aid at all. Indeed, Berlin’s net unemployment rate (with no subsidies) 18.7% was almost equal to the East German average 18.21%. The aid reduced it to 16.6%, having tripled the deviation from the mean from +0.49% to −1.61% (compare the middle and top plots). Besides, due to a large population, reducing Berlin’s unemployment by one percent is much more costly for grant-givers than in small regions. It means that half Bio EUR unnecessarily and irrationally spent for Berlin could be used for other regions with much greater urgency and with much higher efficiency. Such planning errors are typical for large towns like Dresden, Magdeburg, and Jena.

Now estimate the efficiency of the actual implementation of the equalization program in 2000–2002. By efficiency we understand the result-to-price ratio. The reference lowest price can be found with the optimization model.

Figure 3 shows the attainable standard deviation of regional unemployment rates $\sigma$ as functions of aid to West and East Germany. As one can see, the actual West German standard deviation $\sigma = 2.1\%$ obtained for 618 Mio EUR could be optimally attained for 241 Mio EUR, which gives the "reference price" of the result.
The case of East Germany is even more surprising. The actual equalization program has increased the regional disparity, having made the standard deviation of regional unemployment rates larger than if with no subsidies. Therefore, the optimal East German ε-curve is below the actual East German'2002 level even for 0-budget, meaning that the "real price" of the result obtained for 5360 Mio EUR is 0. Thus, the efficiency of the program in 2000–2002 is

\[
\text{Policy efficiency} = \frac{\text{Result}}{\text{Investment}} = \frac{(241+0) \cdot 100\%}{618+5350} \approx 4\%
\]

3 Managing regional policy

Potential of subsidies

Explore the potential of subsidies to regional labour markets in 2004 based on predictions from years 1994–2002 (also for the budget).

The top plot in Figure 4 depicts the effect of optimal subsidies with respect to the target Minimal Unemployment. The ‘skyline’ contour shows the predicted regional net unemployment, whereas the coloured part shows the residual unemployment after the subsidies have been applied. As one can see, the model exhausts the unemployment in the regions with the most ‘cheap’ jobs. Such a policy reduces the (weighted) East and West German unemployment rate by 0.4% and 2.9%, but increases its regional standard deviation by 0.3% and 5.9%, respectively.

The second plot in Figure 4 depicts the effect of optimal subsidies with respect to the target Maximal GDP Gain. As one can expect, the model channels the grant to the regions with the highest productivity. The effects of this policy with respect to all the three targets, unemployment reduction/equalization and GDP gain, are very close to the one obtained with target Unemployment. It means that most productive jobs are at the same time most cheap for grant-givers, because highly competitive industries can create new jobs with little aid.

The third plot in Figure 4 depicts the effect of optimal subsidies with respect to the target Unemployment Equalization. The model channels the aid to the regions with a high net unemployment rates which reduction is relatively ‘cheap’, reducing their standard deviation by 0.5% in West Germany and by 1.5% in the East Germany, contrary to its significant increase in previous two models. The reduction of unemployment and the GDP gain are however significantly lower. as 3.1 Bio EUR (188%-return from the aid).

The effect of considering all the three targets with a sample weight ratio 4 : 1 : 15 is shown in the bottom plot of Figure 4. A certain degree of equalization is obtained, and the indices of unemployment and GDP gain are significantly better than in the previous case.
Fig. 4. Potential of subsidies to German regions in 2004 predicted from years 1994–2002
Triangle of priorities

A target weight ratio like $a : b : c = 4 : 1 : 15$ says little to a policy maker. Much more useful is the triplet of target variables attainable under the given ratio. Such triplets for East Germany are collected in the triangle of priorities in Table 2 for the target weights in 0.1 steps. If necessary, the step can be obviously refined. Each table cell is associated with certain weights $0 \leq c \leq 1$ of the equalization target and $0 \leq b \leq 1$ of the GDP target. The normalized weight $a = 1 - b - c$ of the unemployment target is indicated at the bottom of the table diagonals. The target values optimized are not monotonic functions of the normalized target weights, since an increase in one weight implies a reduction of another weight which can break the monotonic response of the optimization model.

Table 2. Triangle of priorities for East Germany in 2004 for the budget 1653 Mio EUR

<table>
<thead>
<tr>
<th>Weighted average unempl. rate $\pm \sigma_{\text{regional unemployment rate}}$ in %</th>
<th>GDP gain, in Mio EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equalization priority</td>
<td>0.1</td>
</tr>
<tr>
<td>1</td>
<td>18.3±2.1</td>
</tr>
<tr>
<td>0.9</td>
<td>18.0±2.2</td>
</tr>
<tr>
<td>0.8</td>
<td>17.6±2.9</td>
</tr>
<tr>
<td>0.7</td>
<td>17.0±3.9</td>
</tr>
<tr>
<td>0.6</td>
<td>16.7±4.7</td>
</tr>
<tr>
<td>Employment priority</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Note that the variation of target values along the table rows is relatively small. It means that in the space of optimal policies, both targets, ‘maximization of employment’ and ‘maximization of GDP’, are operationally highly correlated. In other words, subsidizing ‘cheap’ jobs leads to supporting most competitive industries and vice versa. We conclude that the three-dimensional policy space can be reduced to two-dimensions, with ‘maximization of employment’ and ‘maximization of GDP’ merging into one factor.
Returns from investments in regional policy

Political decisions are often made within certain budget flexibility. The model discussed can predict the triplets of target indices for variable budgets, enabling to trace the effect-to-budget ratio. The task is simplified due to a high correlation of the ‘Employment’ and ‘GDP’ target indices. Therefore, it suffices to consider variable budgets only for the target weight ratios ‘Employment/Equalization’.

Consider normalized target weights $0 \leq \alpha \leq 1, \beta = 1 - \alpha$. Since a uniquely determines $c$, the variety of weight ratios is one-dimensional. It allows us to represent variable target ratios versus variable budgets by a two-dimensional Table 3 (for East Germany). The vertical dimension, ‘Equalization priority’ shows the weight $c$ in 0.05.

Table 3. Estimated returns from investments in regional policy of East Germany in 2004

<table>
<thead>
<tr>
<th>Equalization priority</th>
<th>Investment in regional policy, in Mio. EUR</th>
<th>GDP gain, in Mio EUR</th>
<th>Profitability, in %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1500</td>
<td>1600</td>
<td>1700</td>
</tr>
<tr>
<td>1</td>
<td>18.3 ± 2.1</td>
<td>18.3 ± 2.1</td>
<td>18.2 ± 2.0</td>
</tr>
<tr>
<td></td>
<td>2826</td>
<td>3011</td>
<td>3200</td>
</tr>
<tr>
<td></td>
<td>−26.3</td>
<td>−26.4</td>
<td>−26.4</td>
</tr>
<tr>
<td>0.95</td>
<td>18.3 ± 2.2</td>
<td>18.2 ± 2.1</td>
<td>18.2 ± 2.0</td>
</tr>
<tr>
<td></td>
<td>3113</td>
<td>3302</td>
<td>3493</td>
</tr>
<tr>
<td></td>
<td>−18.9</td>
<td>−19.3</td>
<td>−19.7</td>
</tr>
<tr>
<td>0.9</td>
<td>18.1 ± 2.3</td>
<td>18.1 ± 2.2</td>
<td>18.0 ± 2.2</td>
</tr>
<tr>
<td></td>
<td>3564</td>
<td>3788</td>
<td>4014</td>
</tr>
<tr>
<td></td>
<td>−7.1</td>
<td>−7.4</td>
<td>−7.7</td>
</tr>
<tr>
<td>0.85</td>
<td>17.9 ± 2.5</td>
<td>17.9 ± 2.4</td>
<td>17.8 ± 2.4</td>
</tr>
<tr>
<td></td>
<td>4222</td>
<td>4461</td>
<td>4708</td>
</tr>
<tr>
<td></td>
<td>10.0</td>
<td>9.0</td>
<td>8.3</td>
</tr>
</tbody>
</table>

steps. The horizontal dimension shows the hypothetical budget for the East German regional policy 2004. Every cell of the table contains four elements. The first three are the three target indices optimized for the given target weights under the given budget. The fourth element of the cell is the ‘Profitability’ of the investment in the regional policy which characterizes the tax returns from additional jobs. For instance, suppose that the GDP increment due to the jobs subsidized for 1 Mio EUR aid is 3 Mio EUR. The taxes from these additional 3 Mio EUR bring the
state 39.1% tax (OECD estimation of the tax ratio in Germany for 2002), or 1.173 Mio EUR. Then

\[
\text{Profitability} = 1.173 - 1 = 0.173 \text{ Mio EUR} \approx 17.3\%.
\]

As one can see, the regional policy becomes profitable if the GDP/Unemployment targets are not totally neglected. The overemphasis on the equalization of regional unemployment is therefore not recommended.

4 Conclusions

The model developed has two political implications. First, comparing with the optimal budget distribution, the efficiency of the actual budget distribution in 2000–2002 is about 4% (Section “Analysis of the past practice”). This figure certainly requires reservations, but still indicates at a considerable room for possible improvements.

A bad implementation of active labour market policies can be the major cause of their low efficiency which is often misinterpreted as their uselessness. Thus, the model provides a counter-argument against neo-liberal claims to abandon “useless” active labour market policies and to deregulate labour markets to the end of enhancing sustainable development.

Secondly, the non-optimality of using European and national grants indicates that a similar situation can be more or less inherent in other domains of public finance. Therefore, before imposing higher taxes, introducing tolls and other charges for tax payers, governments should pay more attention to a better use of their own budgets.

As for specific OR issues, the model reveals a high operational dependence between two policy targets, maximization of employment and maximization of GDP (Triangle of priorities). It means that subsidizing jobs in productive branches best contributes to the competitiveness of the national economy and most efficiently reduces unemployment. Overemphasizing the equalization reduces the competitiveness 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. The equilibrium in West Germany was violated, which reduced the competitiveness of West German industry and caused high unemployment. On the other hand, the released funds transferred to East Germany turned out to be insufficient, resulting in no East–West equalization.

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

Finally, it should be emphasized, that practical applications of the model are supported by the user-friendly visual interface.
Annex: Model

Derive regional time series from Table 1:

\[
\text{Net employed} = \text{Number of employed} - \text{Number of jobs subsidized} \\
\text{Net unemployed} = \text{Number of unemployed} + \text{Number of jobs subsidized} \\
\text{Productivity} = \frac{\text{GDP}}{\text{Number of employed}} \\
\text{Aid per job subsidized} = \frac{\text{Aid to the region}}{\text{Number of jobs subsidized}}
\]

The numbers of net employed and net unemployed are computed as if with no aid. The productivity reflects the competitive standing of the region. Supporting productive regions gives a higher gain in the GDP. The aid per job is the price of one job for grant-givers. Subsidizing the regions with cheap jobs brings more jobs for the same expenditures.

Depending on the application of the model, for analyzing the past practice, or for making future planning, the time series are either restricted to the years 2000–2002, or used to make predictions for 2004. In both cases obtain five 271-vectors with regional figures for the control period:

\(u\) net unemployed (with no subsidies), in Ths
\(n\) net unemployment rate (with no subsidies), in %
\(j\) additional jobs subsidized with 1 Mio EUR, in Ths
\(g\) GDP gain due to jobs subsidized with 1 Mio EUR, in Mio EUR
\(d\) decrement in unemployment rate due to jobs subsidized with 1 Mio EUR, in %

Unknown budget distribution and target variables

\(x\) the (unknown) 271-vector of subsidies to the regions in the control period, in Mio EUR

\[t_1(x) = j^\top x\] the total additional number of jobs in the control period due to subsidies \(x\); where \(\top\) is the vector/matrix transpose and \(jx\) is the scalar product of two vectors

\[t_2(x) = g^\top x\] the total gain in the national GDP due to subsidies \(x\), in Mio EUR
\( t_r(x) = \text{Var}(n - d \cdot x) \) the variance of regional unemployment rates attainable due to subsidies \( x \), in \( \% \). denotes the element-by-element product of vectors, for instance \((1,2),(3,4) = (3,8)\).

**Lemma (Unemployment disparity among regions)**

The variance of \( m \) regional unemployment rates attainable due to subsidies \( x \) is

\[
t_r(x) = \text{Var}(n - Dx) = \frac{1}{m-1} (x'VDx - 2n'VDx + n'Vn),
\]

where \( D \) is the diagonal matrix with the elements of vector \( d \) on its main diagonal.

**Theorem (Optimization model)** Given total budget \( B \), list of the regions eligible to receive subsidies, and importance ratio of three target variables \( a: b: c \), then the optimal aid distribution \( x = \{x_i\} \) is found from the quadratic programming problem

\[
\text{maximize } \quad a t_1(x) + b t_2(x) - c t_3(x) = -x' \left( \frac{c}{m-1} D'V D \right) x + (2c n'V D + a j + b g)' x
\]

subject to \( \sum x_r \leq B \) (budget constraint)

\[
0 \leq j \leq u \quad \text{(fewer jobs aided than unempl.)}
\]

\[ x_r = 0 \quad \text{for non-eligible regions } r,
\]

where \( J \) is the diagonal matrix with elements of vector \( j \) on its main diagonal.

The Hessian \( D'VD \) of the objective function (1) is symmetric implying the problem solvability.

The dimensionality \( m \) of the model for West Germany (size of vectors) is 204 and for East Germany 67.

Throughout the paper, the target weights \( a, b, c \) are given for the target variables normalized to 0–1; the target limits are obtained from solving three one-target problems (with all the weights but one equal to 0):

\[
t_{\text{normal}} = \frac{t - t_{\text{min}}}{t_{\text{max}} - t_{\text{min}}}
\]

\[
t = t_{\text{normal}}(t_{\text{max}} - t_{\text{min}}) + t_{\text{min}}
\]

**References**


